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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 976

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER January 20, 1922

CULTURAL EXPERIMENTS WITH GRAIN SORGHUMS IN THE TEXAS PANHANDLE

By

BENTON E. ROTHGEB, formerly Assistant Agronomist in Charge of Grain-Sorghum and Broom-Corn Investigations, Office of Cereal Investigations

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HISTORY OF THE EXPERIMENTS.

THE OFFICE OF CEREAL INVESTIGATIONS began experiments with grain sorghums in the Panhandle of Texas in 1904. These experiments were conducted for three years at Channing, Tex., on the the X I T Ranch. In 1906 the work was transferred to Amarillo, Tex., where it was continued until the close of the season of 1919. Early results indicated that these crops were well adapted to Panhandle conditions, and the demand for information concerning them resulted in the expansion of the work, beginning in 1908.

The data obtained are the basis of many statements made in numerous popular and scientific publications.[1] The detailed data obtained from the varietal experiments in the 9-year period from 1908 to 1916, inclusive, are published in Department Bulletin No. 698. The detailed results from the date-of-seeding, rate-of-seeding, and environmental experiments during the 6-year period from 1914 to 1919, inclusive, are presented herein.

[1] A list of these publications is printed at the end of this bulletin.

DESCRIPTION OF THE AMARILLO CEREAL FIELD STATION.

LOCATION.

The results obtained at the Amarillo Cereal Field Station are applicable to a large part of the Panhandle of Texas (fig. 1) and to

FIG. 1.—Sketch map of the Panhandle section of Texas and the surrounding country. The Panhandle section as considered in this bulletin is shown by the shaded boundary.

adjacent portions of New Mexico and Oklahoma having similar climatic conditions. To help determine just how far these results are applicable to other localities, it is desirable to know the physical factors obtaining at the Amarillo Cereal Field Station which influ-

ence crop growth. These factors are described in detail, in order that such comparisons may be made.

The Amarillo Cereal Field Station (fig. 2) is located about 2½ miles northeast of the city of Amarillo, the county seat of Potter County,

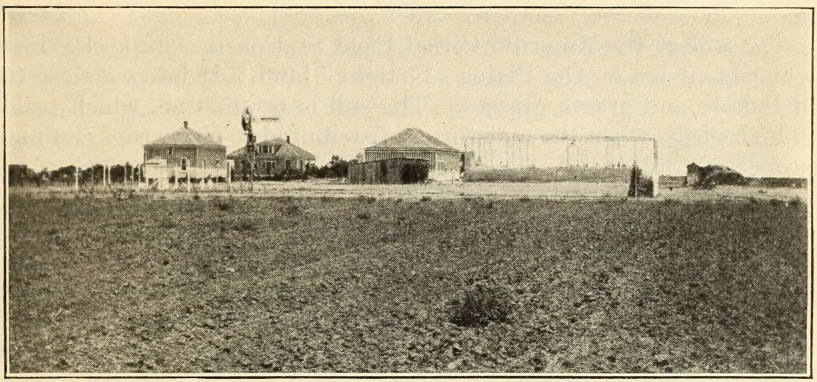

FIG. 2.—Amarillo Cereal Field Station, rear view, showing weather instruments, farm buildings, and screened inclosure for cooperative transpiration studies, 1913.

Tex. It contains 120 acres of level prairie land at an altitude of approximately 3,600 feet above sea level. This portion of the State was used almost entirely for grazing cattle until recently. During

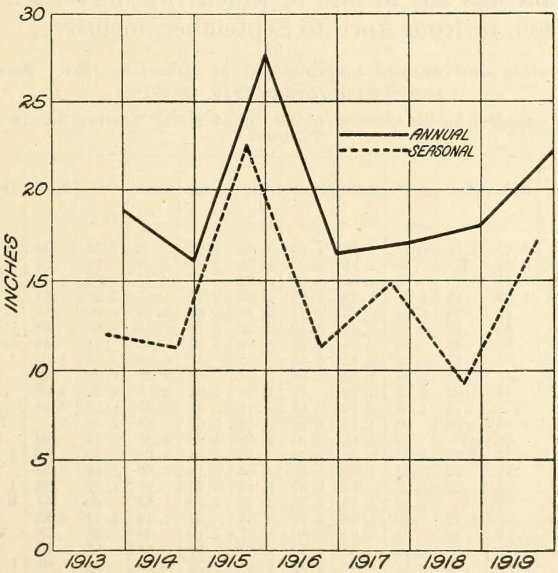

FIG. 3.—Annual and seasonal (April to September) precipitation, in inches, at the Amarillo Cereal Field Station during the 7-year period from 1913 to 1919, inclusive.

the past 20 years most of the large ranches have been divided and fenced into smaller farms. Large fields of grain sorghums, wheat, and oats may now be seen, breaking the monotony of the great expanse of level prairie.

PHYSICAL FACTORS.

The more important physical factors which usually influence crop production are (1) the soil, (2) the annual and seasonal rainfall and its distribution, and (3) the seasonal evaporation and temperature.

SOIL.

The soil at the Amarillo Cereal Field Station is a dark clay loam, which is known on the Plains as "tight" land. It bears a close turf of buffalo and grama grasses. The soil is productive, which results in high yields when the moisture is distributed so that crops can make proper use of it.

RAINFALL.

Precipitation and its distribution probably are the prime factors in crop production in the section of the Plains in which the Amarillo Cereal Field Station is located. There is usually moisture enough to grow a crop, but it is not always so distributed that the crop can make the best use of it. When it is not, crop yields are low, and in extreme cases total failures result.

MONTHLY AND ANNUAL PRECIPITATION.

Table I shows the monthly, annual, and mean annual precipitation, in inches, at Amarillo, Tex., during the 28-year period from 1892 to 1919, inclusive. The mean annual precipitation at Amarillo for these 28 years was $20\frac{4}{5}$ inches, of which $15\frac{2}{5}$ inches fell during the growing season, or from April to September, inclusive.

TABLE I.—*Monthly and annual precipitation at Amarillo, Tex., during the 28-year period from 1892 to 1919, inclusive.*

[Data (in inches) furnished by the observer of the United States Weather Bureau at Amarillo, Tex. T.=trace.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Mean annual.
1892	0.42	0.57	2.10	0.21	2.70	1.49	1.85	1.93	0.24	2.85	0.16	1.08	15.60	.....
1893	.09	2.03	T.	.16	2.19	2.03	2.05	2.67	5.27	.03	.28	.43	17.23	16.42
1894	.02	1.15	.05	.85	1.30	3.59	1.82	3.41	2.41	.59	0	.82	15.81	16.21
1895	1.60	1.92	.16	1.31	1.78	6.84	2.08	3.87	.57	2.26	.81	.79	24.79	18.36
1896	.76	.41	.21	1.95	2.20	2.31	7.04	.63	2.45	3.09	.35	2.68	24.28	19.54
1897	2.26	.65	.47	1.08	4.44	2.32	2.16	2.71	.73	1.63	.08	.63	19.16	19.48
1898	.86	.82	.36	.98	3.52	4.81	3.88	4.03	.48	.41	.34	2.06	22.54	19.91
1899	.29	.07	.17	.23	3.12	4.45	6.96	.51	6.09	1.15	3.24	1.11	27.39	20.85
1900	.59	.47	.48	5.47	4.53	1.84	3.21	.83	5.25	1.58	.98	.07	24.40	21.24
1901	.03	.48	.02	4.90	5.99	.92	1.66	3.03	2.19	3.26	2.00	.04	24.42	21.56
1902	.04	T.	.74	1.83	9.14	2.01	1.45	2.42	.95	1.74	2.24	.55	23.11	21.70
1903	.12	2.93	.26	.90	1.79	2.83	3.38	4.67	.82	2.58	0	T.	20.28	21.58
1904	.16	.08	T.	.63	2.88	5.53	2.48	4.69	3.55	.44	.20	.69	21.33	21.56
1905	1.00	1.52	2.62	4.52	6.16	2.19	3.76	.63	3.08	.30	5.09	1.45	32.32	22.33
1906	.41	.51	.64	3.23	1.18	2.07	2.90	6.76	1.96	2.49	2.58	.19	24.92	22.50
1907	1.11	.24	.02	1.25	.99	1.97	1.49	6.20	.91	1.79	.66	1.46	18.09	22.22
1908	.26	.72	T.	1.90	3.55	1.75	5.40	2.75	1.83	.40	.51	0	19.05	22.04
1909	.07	.22	1.20	.50	1.08	4.72	3.63	.87	2.19	1.18	3.25	.54	19.59	21.90
1910	.05	.17	.34	.59	2.99	.66	3.57	2.19	.05	.26	.28	T.	11.15	21.34
1911	.13	2.88	.50	2.76	5.88	.20	3.85	2.97	.85	.84	.94	.95	22.73	21.41
1912	T.	1.94	.82	.72	1.67	1.90	1.88	2.28	2.28	.39	.02	1.18	15.08	21.10
1913	.11	55	.59	1.76	1.41	2.32	1.80	.61	4.19	.61	1.98	2.84	18.97	21.01
1914	.06	.10	.15	.95	4.43	.84	3.07	2.97	1.07	4.46	T.	1.17	19.27	20.93
1915	.72	1.60	1.00	5.05	1.70	1.04	4.14	5.85	4.69	1.55	.18	.13	27.64	21.21
1916	.36	.02	.57	1.71	.89	2.18	.94	3.82	1.76	2.90	.40	.88	16.43	21.02
1917	.69	.22	.25	.71	2.49	.83	2.68	6.17	2.05	.34	.59	.04	17.06	20.89
1918	1.01	.26	1.06	.48	2.23	1.43	2.23	2.36	.64	2.47	1.16	2.78	18.11	20.74
1919	T.	.73	1.73	2.56	2.08	2.94	1.75	3.21	4.58	.67	1.26	.50	22.01	20.81
Average.	.47	.83	.59	1.72	3.01	2.43	2.96	3.04	2.25	1.47	1.05	.89	20.81	.....

Both the monthly and the annual precipitation fluctuate widely, as is shown in Table I. The rainfall in April amounted to less than three-tenths inch in several different years and to more than 5 inches in several other years, which is a difference of almost 5 inches between the extremes. June, July, August, and September each has about the same range of fluctuation as April. May has a wider range, amounting to about 8 inches. In the annual precipitation the extreme range is from 11 inches in 1910 to 32 inches in 1905.

TABLE II.—*Daily and monthly precipitation at Amarillo, Tex., during the 6-year period from 1914 to 1919, inclusive.*

[Data (in inches) furnished by the observer of the United States Weather Bureau at Amarillo, Tex. T.=trace.]

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1914:													
1					0.96		0.57						
2				0.04		0.06	.04	0.62					
3	T.			.17	T.								
4							.22	.67					
5		T.						.11					
6				.43			.63		0.30				
7				.17		.10	.07						
8													
9								.58					
10				.10				.41	.31				
11			T.	.01					.29	0.09			
12								T.	.15				
13													
14					.05	.05				T.			
15					.48	.01			.01				
16					.81								
17					.09		.21						
18				.11	.47								
19					.07		.11						
20			0.01		T.	.43						0.43	
21					T.				T.	.15			
22				.01					.04	2.28			
23										1.46			
24												.44	
25							.02						
26				.06	T.								
27		0.01			.22		.03						
28				T.	.47								
29			.01	.03	.02			.13					
30				.19	T.	T.							
31					.20								
Total	T.	.01	.02	1.27	3.83	.65	1.90	2.52	1.10	3.98	0	.87	16.15
1915:													
1						.22	.02	.02					
2			.20	T.		.03	.01						
3		T.	.10				.06						
4			.25			.23	.33						
5					T.	T.	T.		T.				
6			T.	.25	.08	T.			T.			.05	
7				.40		.01		T.					
8			.04	.25			T.	.73					
9			.17	.01			.01	.32					
10											T.		
11								T.		.21			
12							.01			.12			
13							.79						
14				.05				2.89		1.13			
15	T.			.65			.61	.36	.11	.09			
16	0.29		T.	.30	.39		1.33	.20	.02				
17				1.34	.44			T.	.34		0.18		
18		T.		T.	.01		T.		.04				
19			T.	.01	T.		.21		.11				
20		.83			.19		.54		T.				
21		T.	T.	.09				.27					
22	.03	T.		.07					.14				
23	.01							.31	.03				
24				.73			.12	.20	.22			T.	
25	T.			.28		.40	.02		3.05		T.		

TABLE II.—*Daily and monthly precipitation at Amarillo, Tex., during the 6-year period from 1914 to 1919, inclusive*—Continued.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1915:													
26	T.	0.58	T.		0.23				0.01				
27		.19			.21	0.06		T.				0.02	
28						.09		0.55					
29	0.01			0.55	.11	T.	0.08		.05				
30	.12			.07	.04	T.	T.		.57				
31	.26		0.24									.06	
Total	.72	1.60	1.00	5.05	1.70	1.04	4.14	5.85	4.69	1.55	0.18	.13	27.65
1916:													
1		.02		T.						T.			
2													
3													
4	T.			.22		1.38							
5						.15							
6				.06		.04			T.				
7				T.				T.				.21	
8								.03	.06		.03	.05	
9					T.								
10	T.		T.						.51	.70		.04	
11	.07				T.		T.		.01	.02	T.		
12		T.		.04		T.	.01		.01	.82	T.		
13				.16		T.		.28		.02	.03		
14			T.	.97		.03		.01		1.07		T.	
15					.01	.35							
16	.05					.12		.04		T.			
17	.12				.88			.14				T.	
18							.02		.17				
19					T.		.19	.27	.01				
20	.11			.12			T.	.99				.16	
21								1.49			.34	.11	
22						.11		.41					
23			9.17					T.	.70				
24									.29	.04			
25	T.			.02									
26	T.			.12									
27	T.						T.						
28	T.	T.					T.			.23			
29	.01						.72						
30	T.			T.			T.	.16				.20	
31			.40					T.				.11	
Total	.36	.02	.57	1.71	.89	2.18	.94	3.82	1.76	2.90	.40	.88	16.43
1917:													
1			T.	T.		T.		1.11	.22				
2							.06		.08				
3			.25				.03						
4					T.		.60	T.					
5					.35			T.					
6					.71								
7								.42				.04	
8									.22	.29			
9					.37		T.					T.	
10				.29	.55			.14	.14				
11				.22			T.	.50					
12	T.			.01				T.	T.				
13	.09		T.	.01	.41			1.02					
14	.36	.22		.05	.02		.06	.06	.80				
15	.13					T.		.50	.38				
16	.04						1.20	.26	.04	T.	.09		
17							.28	.61			.08		
18		T.		.13	.04	T.				T.	.36		
19				T.	T.	.54		1.08					
20	.01					.01		.01					
21					.03	T.		.68					
22	.06					.28		.10					
23						T.			.02				
24					T.				T.				
25													
26			T.			T.			.15				
27					.01			.12			.06		
28				T.				.01					
29										.05			
30													
31							.45						
Total	.69	.22	.25	.71	2.49	.83	2.68	6.17	2.05	.34	.59	.04	17.06

TABLE II.—*Daily and monthly precipitation at Amarillo, Tex., during the 6-year period from 1914 to 1919, inclusive*—Continued.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918:													
1							T.						
2			0.07			0.01	T.		0.07				
3			.02		0.14	T.			.06				
4					T.	T.			.01				
5					.17	.01			.31				
6						.11		0.11					
7						1.20		1.28			0.04		
8				0.31			0.01	.42					
9						T.	T.	.28		0.04			
10	0.48						T.			T.			
11		0.26			.17		T.			.01			
12							.34					0.06	
13				.13									
14	.03										.01		
15	.17						.33	.05	.04				
16				T.			.44	T.	.13		.03	.20	
17												.57	
18				.01			.07	.20		.06			
19	.26			.03				T.		.17		.77	
20	.03			T.						.01		.04	
21			T.				.01			1.43			
22							.27			.01	.06	.47	
23								.01		.03	.05	.39	
24					.09			.01			.46		
25					.22		T.			.27	.46		
26	T.					T.			.02	.43	.05		
27	.03	T.			.15	.03				.01			
28		T.	.44		.43								
29			.52		.05	T.	.02	T.		T.			
30	.01		.01		.81	.07	.74					.05	
31												.23	
Total	1.01	.26	1.06	.48	2.23	1.43	2.23	2.36	.64	2.47	1.16	2.78	18.11
1919:													
1		.09		.01	.01	T.	T.					.02	
2				.61		T.						.01	
3				.13		.05		.08				.01	
4						.01				T.			
5					T.			T.		.25	T.	T.	
6			T.	T.	.64					.04			
7			.12					1.42		.07	T.		
8		T.	T.	.19	T.		T.	.15		.09	.60	.05	
9				.61		1.34		.91			.17		
10			.06		.43	.16			T.	.11			
11					.07	.70			T.				
12		.04				T.	.05			.04			
13	T.	T.			.02		.05						
14	T.					.39	T.						
15			T.			.09	.06		1.33				
16							.02		1.89				
17							1.29	.07	1.36				
18						.01	.27	.28				.34	
19		.24				.08	.01	.30			T.	.07	
20							T.				T.		
21		.32	T.										
22			.22		T.								
23			.78		.11								
24			.55	.07	.55	.11							
25		.03		.60	.32						.20		
26	T.			.31	.03					T.	.08		
27				.03	.08					T.	.08		
28		.01									.13		
29			T.	T.			T.			.03			
30					.02				T.	.04			
31								T.					
Total	T.	.73	1.73	2.56	2.08	2.94	1.75	3.21	4.58	.67	1.26	.50	22.01

DISTRIBUTION OF MONTHLY RAINFALL.

The total annual and seasonal rainfall in the 7-year period from 1913 to 1919, inclusive, which is shown graphically in figure 3, easily may be misleading. Because of the irregular distribution of the

seasonal rainfall, the varying quantities deposited by different showers and the manner in which it falls are not shown. These will be better understood by a careful study of the data in Table II, which contains a record of the daily rainfall, with monthly totals, throughout the 6-year period from 1914 to 1919, inclusive.

The annual and seasonal rainfall was sufficient to produce fair to good yields of the grain-sorghum crops in all the years during which these experiments were conducted; but in several seasons the low yields obtained were due largely to the unfavorable distribution of the moisture. This may occur in several ways: (1) Much of the

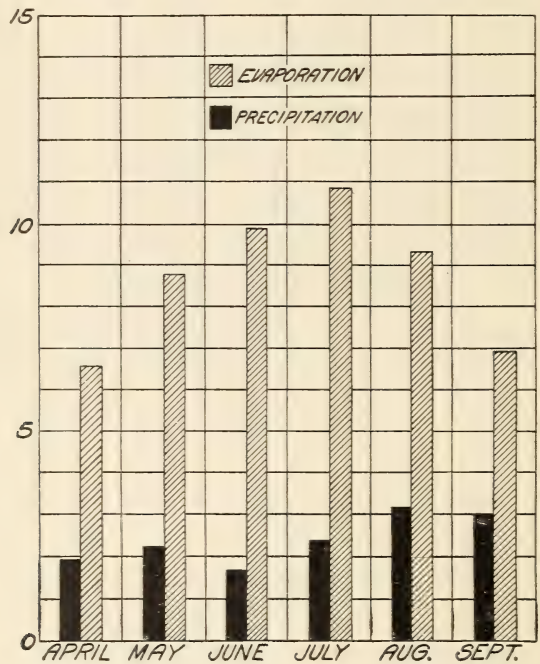

FIG. 4.—Average monthly precipitation and evaporation, in inches, at the Amarillo Cereal Field Station during the growing season (April to September) in the 7-year period from 1913 to 1919, inclusive.

annual rainfall may come within a short period, either near the beginning, in the middle, or at the end of the year; (2) the seasonal rainfall may be sufficient in quantity but poorly distributed; or (3) the rainfall may be fairly evenly distributed and about sufficient in quantity and yet be unsuitable for crop production, as when it occurs in light showers which do not penetrate the soil and are soon evaporated. The seasons of 1916 and 1918 are good examples of the last-mentioned condition. Showers amounting to less than half an inch may add little or no moisture if followed by high winds and bright sunshine, which cause rapid evaporation.

TEMPERATURE.

The data on mean, maximum, and minimum temperatures, by months, for the growing season (April to September) in the 6-year period from 1914 to 1919, inclusive, are given in Table III. The summer days usually are warm to hot, followed by cool nights, which gives a wide range of temperature during the 24 hours. The maximum temperature frequently goes near the 100° F. mark, but seldom exceeds it. June 29, 1918, was the hottest day recorded in this 6-year period. On that date the temperature registered 106° F.

TABLE III.—*Monthly data on temperature and wind movement recorded at Amarillo, Tex., in the six months from April to September, inclusive, each year, during the 6-year period from 1914 to 1919, inclusive.*

Year and month.	Temperature.					Wind.		
	Mean.	Maximum.		Minimum.		Prevailing direction.	Monthly movement.	Highest hourly movement.
		Reading.	Date.	Reading.	Date.			
	°F.	°F.		°F.			*Miles.*	*Miles.*
Season of 1914:								
April	56	88	21	20	8	SW.	9,827	40
May	63	95	10	42	12	S.	8,416	37
June	76	99	26	57	17	SW.	10,429	40
July	78	97	31	60	2	S.	6,023	40
August	76	94	31	57	28	S.	6,559	31
September	73	98	6	49	28	S.	7,938	40
Season of 1915:								
April	57	88	28	29	1	S.	7,997	46
May	62	92	25	30	7	S.	9,263	44
June	72	103	20	42	7	S.	8,841	37
July	75	102	11	52	5	S.	8,893	44
August	71	95	4	48	30	S.	6,232	27
September	69	94	10	47	30	S.	7,860	33
Season of 1916:								
April	53	87	11	26	8	NE.	9,123	42
May	67	98	31	35	1	SW.	9,585	37
June	75	100	21	50	7	S.	8,988	35
July	79	100	3	61	7	S.	6,856	25
August	77	97	13	55	28	S.	7,652	39
September	68	91	10	40	29	S.	8,174	35
Season of 1917:								
April	55	90	23	26	8	S.	10,157	42
May	58	98	17	30	7	SE.	9,032	25
June	74	100	12	38	2	SE.	8,972	40
July	79	100	14	58	4	S.	8,393	32
August	74	95	7	49	29	S.	7,147	39
September	69	94	7	40	27	SE.	6,4	35
Season of 1918:								
April	53	87	26	31	21	SW.	8,176	37
May	68	93	24	35	10	S.	8,943	32
June	77	106	29	54	1	S.	6,727	26
July	78	99	10	58	1	S.	7,823	32
August	78	98	2	55	31	S.	7,898	38
September	65	99	14	37	20	S.	8,176	26
Season of 1919:								
April	55	88	21	26	10	SW.	8,417	44
May	62	87	3	45	20	NE.	7,060	39
June	69	90	7	38	2	SE.	6,561	42
July	76	95	11	61	22	S.	8,341	35
August	78	101	6	60	8	S.	6,760	38
September	71	99	2	47	23	S.	7,730	31

In winter the temperature sometimes reaches zero, and occasionally lower temperatures occur for short periods only. The average date of the last spring frost is about April 19 and that of the first fall frost October 30, leaving an average frost-free period of 194 days.

WIND.

Data on wind movement are shown in Table III; also data on temperature. The total wind movement is high for each month during the season in this 6-year period. The lowest total movement recorded in any month was 6,023 miles for July, 1914, and the highest, 10,429 miles, or an average of 14.3 miles per hour, for June of the same year. Some days are calm and others are partly so. On other days the wind reaches a very high velocity. A maximum velocity of 35 to 45 miles per hour is not uncommon. Such high winds are often injurious to the grain-sorghum crops. They may cause damage by covering the young plants, by cutting them off with moving particles of soil, by whipping the half-grown plants into shreds, or by blowing down the crop when it is approaching maturity.

EVAPORATION.

A great quantity of moisture is lost by evaporation at the Amarillo Cereal Field Station. The prime factors influencing evaporation are precipitation, wind, temperature, and sunshine. The highest evaporation naturally occurs in periods of low precipitation, high temperatures, strong winds, and bright sunshine.

Table IV shows the monthly precipitation and evaporation at the station during the six months from April to September in each year of the 7-year period from 1913 to 1919, inclusive. The evaporation measured is from the free water surface of a tank 8 feet in diameter. These data also are shown graphically in figure 4, where the enormous difference between the precipitation and evaporation may be noted at a glance. On the average during this period the evaporation was 3.75 times as great as the precipitation. July has a higher rate of evaporation than any other month, averaging 10.8 inches in this 6-year period; August has an average of 9.3 inches.

TABLE IV.—*Monthly, seasonal, and 7-year monthly average precipitation and evaporation at the Amarillo Cereal Field Station during the six months from April to September, inclusive, in the 7-year period from 1913 to 1919, inclusive.*

[Data (in inches) obtained at the Amarillo Cereal Field Station in cooperation with the Office of Biophysical Investigations and the Office of Dry-Land Agriculture of the Bureau of Plant Industry, United States Department of Agriculture.]

Year.	April.		May.		June.		July.		August.		September.		Seasonal total.	
	Prec.	Evap.	Prec.	Evap.	Prec.	Evap.	Prec.	Evap.	Prec.	Evap.	Prec.	Evap.	Prec.	Evap.
1913	1.7	7.7	1.7	9.8	2.3	7.0	1.4	12.7	0.5	10.3	5.6	5.9	13.2	53.4
1914	1.3	6.7	3.8	6.7	.7	10.1	1.9	8.7	2.5	8.9	1.1	8.0	11.3	49.1
1915	4.8	4.6	2.0	6.9	1.2	8.8	3.7	9.3	4.6	7.3	4.9	6.0	21.2	42.9
1916	1.8	6.0	.9	10.3	2.7	10.7	1.2	11.7	3.4	10.2	2.2	7.7	12.2	56.6
1917	.6	7.7	2.8	7.6	.7	12.5	2.6	12.4	5.5	8.6	2.1	6.0	14.3	64.7
1918	.5	7.0	2.4	11.0	1.2	10.1	2.7	10.7	2.2	10.3	.7	7.4	9.7	56.6
1919	2.5	6.8	2.0	8.7	3.5	9.9	2.4	10.3	3.4	9.2	4.7	7.2	18.4	52.9
Average	1.9	6.6	2.2	8.7	1.6	9.9	2.3	10.8	3.2	9.3	3.0	6.9	14.3	53.7

EXPERIMENTAL METHODS.

The prime objects in conducting the experiments reported herein were to determine the best time to sow the crop and the rate of seeding from which the best yield can be obtained and to compare yield and composition of crops from home-grown seed with those from imported seed. These experiments were conducted in plats under conditions which conform as closely as possible to good farm practices.

PLAT EXPERIMENTS.

The plats used in these experiments were 8 rods long by 1 or 2 rods wide, containing either a twentieth or a tenth of an acre each. The rows were 132 feet long and 42 inches apart, each row representing approximately 0.01 of an acre. In some cases 10 rows constituted a plat, and in others 5 rows. In sowing the seed the rows were made longer than 132 feet, and when the plants were about 1 foot high the ends of the rows were trimmed to the proper length. Each plat was bordered on either end by a road, but the sides of the plats adjacent to the roads at the ends of the series were protected by guard rows from undue influence from that source.

CROP ROTATION.

The crop rotation practiced on the experimental area for at least the past six years has been cowpeas, small grains, and grain sorghums, in the order named.

METHOD OF SEEDING.

A 2-row corn drill fitted with special sorghum plates was used for sowing the crop in all these experiments. Seeding was done at a rate heavy enough to insure a thick stand under normal conditions, with the idea of obtaining a stand sufficient for these experiments if the conditions were unfavorable. Occasionally, the desired stand was not obtained. When the plants were from 6 to 10 inches high the plats were thinned by hand, wherever possible, to the stands desired.

METHODS OF OBTAINING DATA.

The data on plant and stalk spacing and on the occurrence of suckers and heads were obtained by actual counts of the plants, stalks, and heads in all the rows of each plat for which such data are presented. The percentage of suckers is determined by dividing the difference between the number of stalks and the number of plants by the number of stalks. The percentage of erect heads in Dwarf milo is determined by dividing the number of erect heads by the total number of heads produced, and the percentage of headed stalks is the number of stalks that bore heads divided by the total number of stalks in the plat. The growing period as given here is the total time elapsing from seeding until the crop is ripe. The

vegetative period is the time from seeding until the heads appear. The fruiting period is the time from the appearance of the heads until the kernels are ripe. The height of the plants is the average of several measurements made at different places in the plat.

Harvesting is done with a corn binder, leaving a stubble about 6 inches high. The bundles are shocked in the field and left from four to six weeks to cure before thrashing is done. They are then hauled to the scales and weighed. The heads usually are cut from the bundles before thrashing is done, but occasionally very dwarf varieties are thrashed without heading the bundles. Thrashing is done with a Keystone No. 1 separator. The thrashed grain is weighed as it comes from the thrasher and the acre yield computed therefrom. The yields are based on 60 pounds to the bushel for kafir and 58 pounds for all other varieties.

ENVIRONING CONDITIONS.

A brief summary of the environing conditions during the 6-year period from 1914 to 1919, inclusive, is given to aid in the interpretation of the results obtained from these experiments.

The season of 1914 was not favorable to high yields. The first three months of the year were without precipitation. April had a number of light showers, but none of them penetrated the soil to any depth. May was unusually wet and cold, which caused poor germination in most plats of the early seedings. June was remarkably dry, and the light rains in July furnished only temporary relief to the crop. The rains in early August stimulated growth, and were followed by about an inch of rainfall in the first 12 days of September, which resulted in only fair yields.

The season of 1915 was exceptionally favorable, resulting in the highest yields in the history of the Amarillo Cereal Field Station. The seasonal rainfall was sufficient and so distributed that the crop at no time suffered for moisture.

Dry and unfavorable conditions obtained during the season of 1916. May was dry. A good rain fell on June 4, followed by a number of light showers during the remainder of the month. July had a few light showers, but the next rain of value did not come until August 20 and 21. This was followed by dry, hot weather during the remainder of the month and the first 10 days of September. The light rains of September furnished only temporary relief, so that very low yields of all grain-sorghum crops resulted.

During the season of 1917 enough moisture fell to grow good crops, but the distribution was poor. The moisture for April was less than half the normal, May was slightly below, and June was almost bone dry, only a few light showers falling. July was normal in rainfall,

and August was abnormally wet. Had the distribution been such that the crop could have made better use of the moisture much higher yields would have resulted.

The season of 1918 was very poor for crops, resulting in low yields. Each month from April to September was below normal in rainfall. The moisture received was reasonably well distributed, but in many small showers which made no impression on a dry soil.

In 1919 the seasonal rainfall was about normal in each month except July, which was 1½ inches less than the normal. At seeding time the temperatures were rather low, and much of the seed rotted in the ground or failed to germinate from other causes, which resulted in thin stands in many plats. Otherwise the season was favorable to

FIG. 5.—Early-sown and late-sown plats of Dwarf milo in the date-of-seeding experiment at the Amarillo Cereal Field Station, Amarillo, Tex., on July 2, 1913.

crop growth, and fair to good yields were obtained, considering the thin stands in many plats.

DATE-OF-SEEDING EXPERIMENTS.

The plan followed in the date-of-seeding experiments was to sow on three dates each year. The first or early seeding was made as early as conditions were at all favorable, which usually is about May 10. The normal time for seeding grain sorghums at the Amarillo Cereal Field Station is about May 25, and the latest these crops can be sown in that locality with any assurance that they will ripen before cool weather or frost is about June 10. The early seeding was made on May 10 in 1915, 1916, and 1919, and on May 11 in 1914 and 1918, but in 1917 seeding was delayed by rains until May 16. The normal seeding was made on May 25 in 1914 and 1917, on May 26 in 1915, on May 27 in 1916, and on May 29 in 1919, but was delayed by rains until

June 3 in 1918. The late seeding was made on June 7 in 1917, on June 9 in 1916, on June 10 in 1914 and 1915, on June 12 in 1918, and on June 20 in 1919.

Four varieties, Dwarf milo (C. I. No. 332), Feterita (C. I. No. 182), Dawn kafir (C. I. No. 340), and Manchu kaoliang (C. I. No. 171), were included in these experiments. One plat of each variety was seeded at an early date, one at a normal date, and one at a late date each year. In the early and late dates the varieties each occupied tenth-acre plats, and in the normal date they occupied twentieth-acre plats for each year during this 6-year period.

The results obtained from the date-of-seeding experiments are shown in Tables V to IX, inclusive. The results for each variety are shown separately first, and the averages of the four varieties are then included in one table to facilitate comparison.

TABLE V.—*Yields and other agronomic data in date-of-seeding experiments with Dwarf milo at the Amarillo Cereal Field Station, each year, during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Year and time of seeding.	Row space.		Length of growing period.			Suckers.	Erect heads.	Height of plants.	Grain in crop.	Yields per acre.		
	Plants.	Stalks.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1914:	*Inches.*	*Inches.*	*Days.*	*Days.*	*Days.*	*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Early	10.3	3.6	73	28	101	64.7	99.6	3.3	31.9	5,260	1,680	29.0
Normal	7.1	3.8	65	26	91	47.2	99.8	3.0	32.4	5,440	1,760	30.3
Late	15.8	3.8	70	26	96	76.1	91.1	3.3	38.3	4,100	1,570	27.1
1915:												
Early	27.4	6.6	84	41	125	75.9	73.0	3.8	40.9	8,320	3,410	58.8
Normal	12.1	4.5	74	45	119	63.0	91.6	4.5	39.3	10,380	4,080	70.3
Late	8.2	3.5	62	36	98	57.7	71.1	3.8	36.9	9,680	3,580	61.7
1916:												
Early	6.9	4.0	80	32	112	42.4	99.3	2.0	18.0	1,000	180	3.1
Normal	7.7	3.7	78	36	114	52.6	100	2.3	27.2	2,060	560	9.7
Late	8.3	4.9	69	26	95	41.4	80.2	2.0	20.3	2,300	470	8.1
1917:												
Early	6.1	3.6	90	15	105	41.3	89.6	3.3	29.5	7,360	2,170	37.4
Normal	6.1	3.4	70	35	105	45.1	78.8	3.3	20.8	4,800	1,000	17.2
Late	10.1	5.8	89	28	117	42.7	70.6	4.3	37.9	5,540	2,100	36.2
1918:												
Early	6.3	5.2	106	26	132	18.6	93.8	2.3	14.9	1,140	170	2.9
Normal	4.7	3.7	83	33	116	21.5	92.1	2.3	15.6	1,800	280	4.8
Late	4.2	3.7	80	27	107	13.2	96.0	2.5	14.7	1,460	215	3.7
1919:												
Early	10.5	4.4	87	36	123	58.1	.....	3.3	25.4	4,600	1,170	20.2
Normal	17.0	5.7	76	27	103	66.4	.....	3.3	48.3	5,840	2,820	48.6
Late	5.7	3.1	63	19	82	46.1	.....	4.0	28.8	4,540	1,310	22.6

DWARF MILO.

Table V shows the agronomic data for Dwarf milo in the date-of-seeding experiments. (Fig. 5.) This table shows that the stands obtained from the different dates of seeding are not comparable in all cases in the same year or in the different years. The row space to the plant ranged from about 5 to 8 inches in 11 of the 18 plats used in the experiment. In 6 of the 7 plats remaining, the row space ranged from 10 to 17 inches, and in the other plat it was 27 inches. The thin

stands resulted from unfavorable conditions at seeding time, which affected germination. In some cases poor germination was due to wet, cold soil, and in others to dry soil. The plants have a tendency to adjust themselves to environing conditions, and where the stands were thin a larger number of suckers were produced than in the thicker stands. This condition reduced materially the differences in row space per stalk between the thick and the thin stands.

In most of the years the early date required longer vegetative and total growing periods than either the normal or late dates. This was

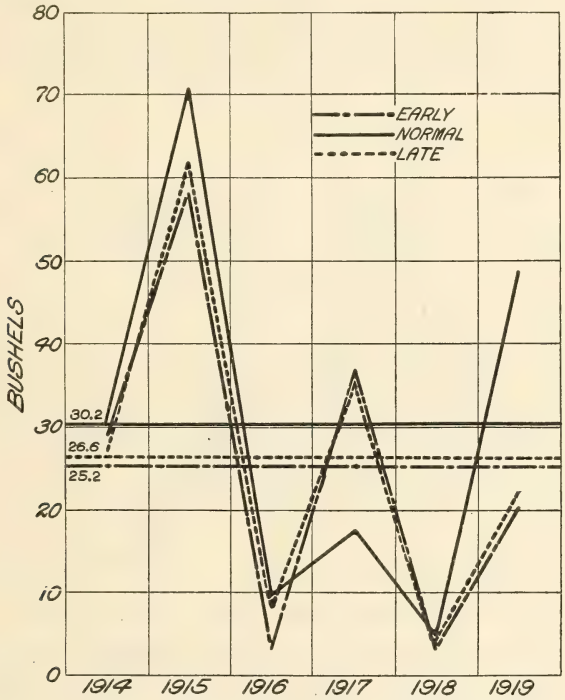

FIG. 6.—Annual and average yields per acre, in bushels, of Dwarf milo (C. I. No. 332) in the date-of-seeding experiments at the Amarillo Cereal Field Station, in the 6-year period from 1914 to 1919, inclusive. Horizontal lines show averages for the period.

due largely to the cold condition of the soil, which prevented normal growth the first few weeks after seeding. The longest time required for the crop to mature was 132 days by the early date in 1918, and the shortest was 82 days by the late date in 1919.

The suckers produced vary with the stands, date of seeding, and seasonal conditions. The thin stands have a higher percentage of suckers than the thick ones in the same season, but the percentage varies with the season. In 1918 but few suckers were produced in any date of seeding. They ranged from 13.2 per cent in the late date to 21.5 per cent in the normal, the early date having 18.6 per cent.

The crop of 1915 has the highest percentage of suckers. That year thin stands were obtained and the season was favorable for luxuriant growth.

The data on erect heads include only the results for five years, from 1914 to 1918, inclusive. During this period the proportion of erect heads ranged from 89.6 to 100 per cent in 10 of the 15 plats for which such data are recorded. In the remaining five plats it is much lower, ranging from 70.6 to 80.2 per cent. No one date of seeding produced the highest percentage of erect heads in all these years, this depending to some extent upon conditions at heading time. It has been observed that more pendent heads occur when the crop is making very rapid growth at heading time than where normal growth only

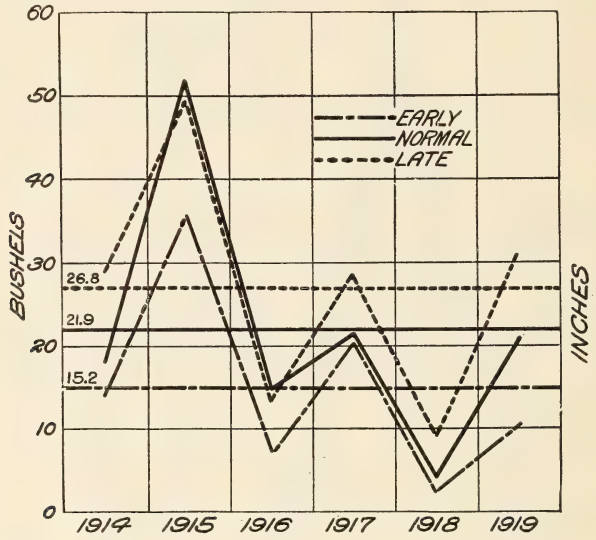

FIG. 7.—Annual and average yields per acre, in bushels, of feterita (C. I. No. 182) in the date-of-seeding experiments at the Amarillo Cereal Field Station in the 6-year period from 1914 to 1919, inclusive. Horizontal lines show averages for the period.

is being made. This may be explained in part by the fact that under conditions which promote rapid growth the sheath unfolds from around the peduncle before it is strong enough to support the head without bending. The degree of curvature of the head depends largely on the strength of the peduncle at the time it is released by the sheath.

The height of the plants ranges from 2 to 4½ feet. The time of seeding apparently has little to do with the height of the plants.

The yield is recorded in three ways: First, the total crop; second, the grain yield in pounds; and, third, the grain yield in bushels of 58 pounds each. The yields are influenced by seasonal conditions to such an extent that no one date of seeding is best for all years and under all conditions. This can be studied best from Table IX, which

shows the averages for all dates in all years. The yields also are graphically shown in figure 6.

FETERITA.

The agronomic data recorded for feterita in the date-of-seeding experiments are shown in Table VI, and the yields are shown also in Table IX, for comparison with other varieties.

TABLE VI.— *Yields and other agronomic data in date-of-seeding experiments with feterita at the Amarillo Cereal Field Station, each year, during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Year and time of seeding.	Row space.		Length of growing period.			Suckers.	Headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plants.	Stalks.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1914:	*Inches.*	*Inches.*	*Days.*	*Days.*	*Days.*	*Per ct.*	*Per ct.*	*Feet.*	*Per ct.*	*Lbs.*	*Lbs.*	*Bush.*
Early	52.8	13.0	73	28	101	75.4	99.0	5.0	25.6	3,160	810	14.0
Normal	11.8	4.9	60	29	89	58.3	63.6	4.5	23.4	4,600	1,075	18.3
Late	17.9	6.1	57	39	96	65.9	88.0	4.3	35.1	4,780	1,680	29.0
1915:												
Early	26.0	5.9	83	40	123	77.1	100	5.5	27.4	7,640	2,100	36.2
Normal	25.0	7.3	68	51	119	70.6	100	5.3	35.1	8,600	3,020	52.1
Late	9.2	4.0	62	36	98	57.0	85.6	5.0	31.1	9,220	2,870	49.5
1916:												
Early	5.4	3.7	80	51	131	32.3	31.8	2.3	21.9	1,960	430	7.4
Normal	8.2	4.2	67	46	113	48.6	48.8	3.0	31.8	2,640	840	14.5
Late	8.3	7.8	64	33	107	6.3	100	3.3	34.5	2,260	780	13.4
1917:												
Early	6.1	3.4	83	24	107	44.5	.....	4.0	20.5	5,800	1,190	20.5
Normal	7.7	3.7	80	25	105	51.3	.....	4.5	20.9	5,920	1,240	21.4
Late	10.7	5.6	74	33	107	47.8	.....	5.0	33.8	4,867	1,645	28.4
1918:												
Early	12.3	8.7	89	50	139	29.3	69.5	3.0	14.6	960	140	2.4
Normal	7.0	5.3	73	43	116	24.6	62.8	3.0	20.0	1,200	240	4.1
Late	5.3	3.8	66	41	107	28.1	62.7	3.3	35.4	1,440	510	8.8
1919:												
Early	35.2	9.1	83	39	122	74.2	100	5.0	14.4	4,240	610	10.5
Normal	63.4	16.1	67	31	98	74.6	100	4.8	41.1	3,920	1,200	20.7
Late	11.7	4.6	52	30	82	60.4	100	4.5	37.5	4,900	1,840	31.7

The stands of feterita in general were not as good as those of Dwarf milo. In 1914 the stand in the early-sown plat was only one plant to approximately 53 inches of row space, and in 1919 the plants in the plats sown on early and normal dates averaged 35.2 inches and 63.4 inches of row space, respectively. These stands produced suckers to the extent of 75 per cent, which reduced the stalk space to distances ranging from 9 to 16 inches. Even then, however, these plats were not directly comparable with the others in the same years. When there is a large number of suckers, usually some of them are late and do not form heads. These tend to increase the total crop yield, but add nothing to the grain yield.

There is a wide range in yield from the different dates in the same year and in the different years. The early date made the low yield each year. The normal date made the high yield in two of the six years, while the late-sown plat led in four years. These yields are compared in Table IX and may be seen at a glance in figure 7.

DAWN KAFIR.

Table VII shows the agronomic data for Dawn kafir in the date-of-seeding experiments. The yields are shown also in Table IX and graphically in figure 8.

Good to fair stands were obtained in most plats in all years during which the experiments were conducted. In most of the plats the row space to the plant ranged from about 5 to 11 inches. A few plats had thinner stands, in one the row space being 26 inches to the plant. On the average the early seeding gave the thinnest stand and the normal seeding the thickest, making a difference of about 3

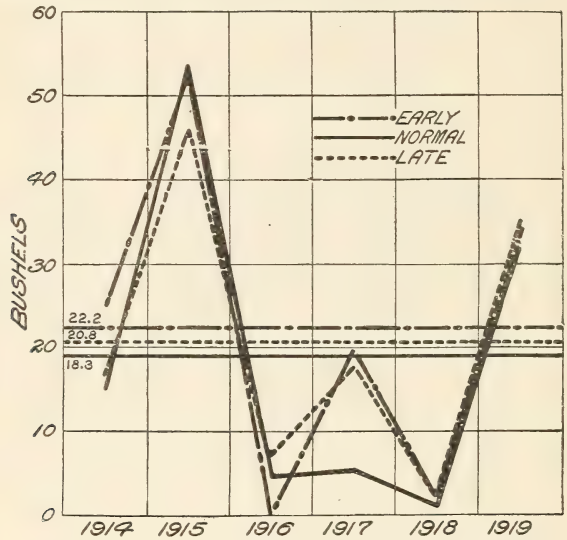

FIG. 8.—Annual and average yields per acre, in bushels, of Dawn (dwarf) kafir (C. I. No. 340) in the date-of-seeding experiments at the Amarillo Cereal Field Station in the 6-year period from 1914 to 1919, inclusive. Horizontal lines show averages for the period.

inches of row space to the plant. These stands are similar to those of Dwarf milo.

The vegetative period ranged from 71 days for the late date in 1914 to 118 days for the normal date in 1916. The total growing period ranged from 93 days for the normal date in 1917 to 156 days for the early date in 1918. The early date usually required a longer total growing period than either of the other seedings. This was due in part to the slow growth made in the early part of the season while the soil temperatures were low and in part to the large number of suckers, which are usually later than the main stalk.

The production of suckers varied greatly in the different seedings in the same year and in the same seeding in the different years. In 1914 the early seeding produced 49.3 per cent of suckers, and the late seeding produced only 12.6 per cent. In 1915 a large number of

suckers was produced on each plat, amounting to over 66 per cent in the early and to more than 45 per cent in each of the other seedings. In the unfavorable season of 1918 few suckers were produced. These amounted to about 14.5 per cent in the early and late seedings and 13 per cent in the normal seeding.

The percentage of stalks bearing heads runs high in the favorable seasons and low in the unfavorable ones. In the season of 1915 the early seeding produced 97 per cent of headed stalks, the normal seeding 94.8 per cent, and the late seeding 91.4 per cent. The maximum of 100 per cent was made by each seeding in 1919. In the poor seasons of 1916 and 1918 the percentage of headed stalks was quite small.

TABLE VII.—*Yields and other agronomic data in date-of-seeding experiments with Dawn kafir at the Amarillo Cereal Field Station, each year, during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Year and time of seeding.	Row space.		Length of growing period.			Suckers.	Headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plants.	Stalks.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1914:	*Inches.*	*Inches.*	*Days.*	*Days.*	*Days.*	*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Early	17.4	8.8	81	32	113	49.3	83.5	3.8	27.4	5,480	1,500	25.0
Normal	5.7	4.8	73	29	102	15.7	61.8	3.0	16.1	5,440	880	14.7
Late	5.9	5.0	71	39	110	12.6	88.5	4.0	21.1	4,750	1,000	16.7
1915:												
Early	19.9	6.6	89	52	141	66.8	97.0	4.5	32.7	9,610	3,150	52.5
Normal	10.2	6.0	81	50	131	45.3	94.8	4.3	36.1	8,860	3,200	53.3
Late	14.5	7.9	80	57	137	45.5	91.4	4.8	27.1	10,220	2,770	46.3
1916:												
Early	7.2	3.8	113	20	133	47.3	11.9	2.5	.....	1,660	No grain.	
Normal	9.1	4.5	118	26	144	50.9	45.2	3.3	4.2	5,200	220	3.7
Late	5.1	3.7	97	18	115	26.1	32.6	3.3	20.0	2,100	420	7.0
1917:												
Early	10.6	4.5	104	23	127	57.3	77.6	4.0	15.5	7,660	1,190	19.8
Normal	10.0	4.3	72	21	93	56.8	52.2	3.8	5.4	5,560	300	5.0
Late	26.0	11.1	89	29	118	57.4	79.3	4.5	21.0	5,040	1,060	17.7
1918:												
Early	7.4	6.3	98	58	156	14.5	17.0	2.3	4.4	2,750	120	2.0
Normal	8.4	7.3	79	57	136	13.2	12.3	2.5	4.7	1,500	70	1.2
Late	5.0	4.2	75	49	124	14.9	11.1	2.3	4.3	2,080	90	1.5
1919:												
Early	10.4	5.2	96	27	123	49.7	100	3.5	29.1	6,980	2,030	33.8
Normal	11.6	5.8	77	30	107	50.1	100	4.0	33.3	5,760	1,920	32.0
Late	5.8	3.8	77	38	115	33.9	100	4.0	32.3	6,560	2,120	35.3

The average height of the plants ranged from 2.3 feet in 1918 to 4.8 feet in the late seeding in 1915. Growing conditions in the vegetative period largely govern the height of the plants. With favorable conditions during this period the height will be greater than with unfavorable conditions when followed by favorable conditions during the fruiting period. Dawn kafir usually attains a height of about 4 feet under average conditions.

The yields vary with seasonal conditions. The highest total yield, 10,220 pounds, was made by the late seeding in the favorable season of 1915, and the lowest, 1,500 pounds, by the normal seeding in the poor season of 1918. Low yields were obtained in 1916. That year the early seeding produced 1,660 pounds of crop; but only 11.9 per

cent of the stalks formed heads, and these did not mature, which made that seeding a failure in grain production.

There is a wide range between the grain yields for the different dates of seeding in the same year and also for the same dates in the different years. Therefore, it is necessary to study the averages to determine the best date to sow. This can be seen in Table IX and at a glance in figure 8.

MANCHU KAOLIANG.

The agronomic data recorded in the date-of-seeding experiments with Manchu kaoliang are shown in Table VIII, and the yields are shown for comparison in Table IX and graphically in figure 9.

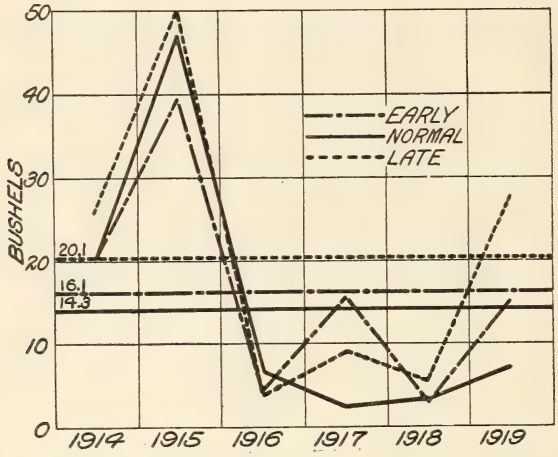

FIG. 9—Annual and average yields per acre, in bushels, of Manchu kaoliang (C I. No. 171) in the date-of-seeding experiments at the Amarillo Cereal Field Station in the 6-year period from 1914 to 1919, inclusive. Horizontal lines show averages for the period.

The stands obtained in most cases were good. In 1916 the normal seeding had a thin stand, averaging one plant to 25½ inches of row space. The late seeding had a very poor stand in 1917, and in 1919 both the early and normal seedings had poor stands. The normal seeding that year was almost a failure, averaging only about 11 plants to the row of 132 feet.

Manchu kaoliang is earlier than any other variety included in these experiments. The vegetative period ranged from 56 days in the late seeding in 1919 to 91 days in the early seeding in 1918. The early seeding usually required the longest and the late seeding the shortest vegetative period. The total growing period ranged from 80 days in the normal seeding in 1914 to 123 days in the early seeding in 1918. Under average conditions from 95 to 100 days are required for this crop to mature.

TABLE VIII.—*Yields and other agronomic data in date-of-seeding experiments with Manchu kaoliang at the Amarillo Cereal Field Station, each year, during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Year and time of seeding.	Row space.		Length of growing period.			Suckers.	Headed.	Height of plants.	Grain in crop.	Yields per acre.		
	Plants.	Stalks.	Vegetative.	Fruiting.	Total.					Total crop.	Grain.	
1914:	*Inches.*	*Inches.*	*Days.*	*Days.*	*Days.*	*P. ct.*	*P. ct.*	*Feet.*	*P. ct.*	*Lbs.*	*Lbs.*	*Bush.*
Early	7.6	7.3	68	21	89	4.8	95.2	5.8	37.5	3,150	1,180	20.3
Normal	6.5	5.1	60	20	80	21.9	97.5	5.3	35.1	3,300	1,160	20.0
Late	6.8	6.6	57	30	87	3.4	97.8	5.0	35.6	4,300	1,530	26.4
1915:												
Early	5.1	4.4	71	42	113	14.0	96.3	6.0	27.9	8,090	2,260	38.9
Normal	4.0	3.8	67	36	103	4.3	92.9	6.5	.....	.....	2,700	46.6
Late	4.2	3.9	58	48	106	7.1	95.6	5.8	36.7	7,810	2,870	49.5
1916:												
Early	5.8	5.2	76	20	96	9.8	43.3	3.8	37.1	700	260	4.5
Normal	25.5	17.7	70	27	97	30.8	86.2	4.0	35.1	1,080	380	6.6
Late	9.9	7.6	64	39	103	23.4	80.7	3.5	20.6	970	200	3.4
1917:												
Early	20.8	9.6	83	16	99	54.0	81.8	5.3	15.5	3,140	890	15.3
Normal	12.6	9.2	83	21	104	27.4	84.5	4.8	5.4	2,080	140	2.4
Late	44.1	20.8	74	26	104	52.8	89.2	5.3	21.0	1,580	500	8.6
1918:												
Early	18.0	15.6	91	32	123	13.3	78.5	4.0	21.4	700	150	2.6
Normal	5.8	5.4	74	20	94	6.7	68.2	3.8	25.0	720	180	3.1
Late	10.7	9.7	68	23	91	8.8	78.7	4.5	25.0	1,240	310	5.3
1919:												
Early	32.6	13.6	73	31	104	58.3	100	5.3	29.8	2,920	870	15.0
Normal	127.7	48.9	69	28	97	61.7	100	5.5	37.0	1,080	400	6.9
Late	13.2	9.1	56	26	82	31.8	100	5.5	43.5	3,860	1,600	27.6

The average number of suckers produced by Manchu kaoliang is not as large as in Dwarf milo, feterita, or Dawn kafir. On the half of the plats used in this experiment on which good stands were obtained, the suckers did not exceed 14 per cent in any one plat. In other plats with thin stands larger percentages of suckers were produced.

In the favorable seasons of 1914, 1915, and 1919 more than 92 per cent of the stalks in each plat produced heads. A much lower percentage was produced in the less favorable seasons, reaching a minimum of 43.3 per cent in the early seeding in 1916.

The height of the plants ranged from 3½ feet in the late seeding in 1916 to 6½ feet in the normal seeding in 1915. The normal seeding produced the tallest and the late seeding the shortest plants during the 6-year period.

The heaviest total crop yield, 8,090 pounds, was made by the early seeding in 1915, and the lightest, 700 pounds, was made by the same seeding in both 1916 and 1918. A study of the averages is necessary to determine the best date of seeding. These are presented in figure 9 and Table IX.

COMPARATIVE YIELDS IN DATE-OF-SEEDING EXPERIMENTS.

Table IX and figures 6 to 9 show the annual and average acre-yields from the early, normal, and late seedings of the four varieties of grain sorghums used in the date-of-seeding experiments.

The annual yields of each variety for each date of seeding are given first, followed in each case by the 6-year average. Dwarf milo made its highest yield, 70.3 bushels, from the normal seeding in 1915, and the lowest yield, 2.9 bushels, from the early seeding in 1918. The normal seeding in this variety yielded highest in five years, and was exceeded by the early seeding in one year. The late seeding made better yields than the early seeding in four of the six years. In average yield during this 6-year period the normal seeding ranks first, with 30.2 bushels, the late seeding takes second place, with an average of 26.6 bushels, and the early seeding is third, with an average of 25.2 bushels. This tends to show that the normal date, from about May 20 to 25, is the best time to sow Dwarf milo in that locality, and that it is safer to delay seeding a little than to sow much earlier than the dates mentioned.

TABLE IX.—*Annual and average yields of four varieties of grain sorghum grown in the date-of-seeding experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds for kafir and at 58 pounds for other sorghums.]

Variety and time of seeding.	Annual yields per acre.						
	1914	1915	1916	1917	1918	1919	Average.
Dwarf milo:	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Early	29.0	58.8	3.1	37.4	2.9	20.2	25.2
Normal	30.3	70.3	9.7	17.2	4.8	48.6	30.2
Late	27.1	61.7	8.1	36.2	3.7	22.6	26.6
Feterita:							
Early	14.0	36.2	7.4	20.5	2.4	10.5	15.2
Normal	18.3	52.1	14.5	21.4	4.1	20.7	21.9
Late	29.0	49.5	13.4	28.4	8.8	31.7	26.8
Dawn kafir:							
Early	25.0	52.5	0	19.8	2.0	33.8	22.2
Normal	14.7	53.3	3.7	5.0	1.2	32.0	18.3
Late	16.7	46.3	7.0	17.7	1.5	35.3	20.8
Manchu kaoliang:							
Early	20.3	38.9	4.5	15.3	2.6	15.0	16.1
Normal	20.0	46.6	6.6	2.4	3.1	6.9	14.3
Late	26.4	49.5	3.4	8.6	5.3	27.6	20.1

The lowest yield of feterita was produced from the early seeding in all six years. The normal seeding made the best yields in two years and the late seeding in four years. On the average the late seeding takes first place with 26.8 bushels, the normal is second with 21.9 bushels, and the early comes last with only 15.2 bushels. The yield from the late seeding on the average is more than 5 bushels larger than that of the normal and over 11 bushels more than from the early seeding. This shows clearly that early seeding should not be practiced with feterita in the Amarillo section.

Dawn kafir made the highest yields from the early seeding in three years and a failure in one year. The normal seeding ranked first in one year and the late seeding ranked first in two years. In the 6-year average the early seeding ranks first with 22.2 bushels, the

late seeding comes second with 20.8 bushels, and the normal seeding takes last place with 18.3 bushels. The averages show that early seeding for Dawn kafir is best and that late seeding is better than the normal date.

Manchu kaoliang produced the best yield in one year from the early seeding, in one year from the normal, and in four years from the late seeding. The late seeding ranks first with an average of 20.1 bushels, the early seeding is second with 16.1 bushels, and the normal seeding is third with an average of only 14.3 bushels. This indicates that Manchu kaoliang should be seeded late if grown at all in this locality, which is true also of feterita.

SPACING EXPERIMENTS.

The spacing experiments were conducted with Dwarf milo (C. I. No. 332) and Dawn kafir (C. I. No. 340). The object of these experiments was to determine the reaction of these crops to the different environing conditions and to determine the distances between plants and rows that would give the best yields. These experiments were divided into two sections. The first section consisted of six plats each year during the 6-year period from 1914 to 1919, inclusive. The rows in these plats were $3\frac{1}{2}$ feet apart (fig. 10), the plants being spaced at different distances, representing six rates of seeding each year. The second section also contained six plats each year. It differs from the first section in the spacing of the rows, which are 7 feet apart (fig. 11), and of the plants, which are twice as thick in the row as in the first section, thus representing the same number of plants per acre.

DWARF MILO.

FIRST SECTION, ROWS $3\frac{1}{2}$ FEET APART.

The agronomic data recorded on Dwarf milo in the first section of the spacing experiments are presented in Table X. This table shows that in 1914 the thickest stand was one plant to 3.7 inches of row space, and that the thinnest stand was one plant to 17.4 inches of row space, with the other four rates ranging from 4.3 to 11.7 inches of row space to the plant. In 1915 the row space to the plant ranged from 6 to 21.4 inches. In 1916 the thickest rate was one plant to 4.2 inches of row space and the thinnest rate was one plant to 20.8 inches. In 1917 the first five rates were practically identical with those of 1915, ranging from 6 inches of row space in the first or thick rate to 18 inches of row space to the plant in the fifth rate. The thin rate had a row space of 24 inches to the plant. In 1918 the row space ranged from 3 inches in the thick rate to 9.1 inches in the fourth rate and 12 and 12.8 inches in the fifth and sixth rates, respectively. In 1919 the germination was poor, making it impracticable to get the

desired stands in all rates. The row space to the plant for the different rates is shown in Table X.

The average stalk space varies much less in the different rates than the plant space, because of the difference in the number of suckers produced per plant in the different rates. The percentage of suckers varies in the different rates in the same year and in the same rates in the different years. In general, however, the percentage of suckers increases as the stand decreases. The thick rate produced 5.8 per cent of suckers in 1918, which was the minimum in the 6-year period. The maximum, 74.4 per cent, was produced

FIG. 10.—Dawn (dwarf) kafir in rows spaced 42 inches apart, plants spaced 12 inches apart, Amarillo Cereal Field Station, Amarillo, Tex., August 17, 1915.

by the thin rate in 1914. It appears that from 65 to 75 per cent, or an average of about three suckers to the plant, is the limit for Dwarf milo and that such rates of suckering may be expected under favorable conditions from plants with 10 to 20 or more inches of row space.

The percentage of erect heads was high in most years, reaching almost 100 per cent in all rates. Thin stands have a greater tendency to produce pendent heads than thick ones, but growing conditions at the time the crop is heading probably are the determining factors in their production. Rapid growth at heading time is favorable to the production of pendent heads.

The yields of the total crop and those of grain in pounds and in bushels of 58 pounds each are recorded in Table X. The thicker

stands usually produced the higher yields in the favorable seasons and the thinner ones in the less favorable years. The highest yield in the different years was not produced by the same stand each year. It is necessary to study the averages to determine the rate which will give the best results during a series of years.

TABLE X.—*Data recorded in the spacing experiments with Dwarf milo grown in rows spaced 3½ feet apart at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Year.	Row space.		Suckers.	Erect heads.	Yields per acre.		
	Plants.	Stalks.			Total crop.	Grain.	
	Inches.	*Inches.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Bushels.*
1914	3.7	2.8	24.6	99.8	5,155	1,255	21.6
	4.3	3.1	29.1	99.8	5,940	1,560	26.9
	6.4	2.9	54.6	99.8	5,480	1,520	26.2
	10.4	3.6	65.6	99.5	5,500	1,470	25.3
	11.7	3.9	66.7	99.6	4,000	860	14.8
	17.4	4.5	74.4	99.2	4,870	1,190	20.5
1915	6.0	3.2	46.3	98.0	9,980	3,900	67.2
	9.0	3.5	60.5	96.2	9,860	3,950	68.1
	12.6	3.8	65.2	96.1	10,430	4,220	72.8
	14.9	4.7	68.0	92.7	9,870	4,210	72.6
	17.7	5.6	68.4	64.7	9,090	3,570	61.5
	21.4	6.3	70.7	73.7	9,330	4,050	69.8
1916	4.2	3.6	14.2	100	2,680	710	12.3
	7.9	4.7	39.8	99.9	1,940	430	7.4
	10.0	5.5	45.4	100	1,700	440	7.6
	11.7	7.5	35.9	99.5	2,360	900	15.5
	15.1	6.6	56.3	99.3	2,980	1,060	18.3
	20.8	10.5	49.6	97.4	2,740	1,120	19.3
1917	6.0	4.0	34.0	81.3	5,720	1,600	27.6
	9.0	3.5	61.2	73.6	5,340	1,520	26.2
	12.0	4.1	66.2	65.8	5,160	1,580	27.3
	14.7	4.9	66.6	67.1	5,900	2,000	34.5
	18.0	4.9	72.6	68.0	5,060	1,480	25.5
	24.0	6.1	74.7	78.4	5,300	1,630	28.1
1918	3.0	2.8	5.8	96.4	1,100	60	1.0
	5.1	4.6	9.7	95.0	1,000	70	1.2
	6.0	5.1	15.1	91.3	960	100	1.7
	9.1	5.8	36.7	89.5	1,440	270	4.7
	12.0	7.8	35.2	87.6	1,240	190	3.3
	12.8	7.9	37.9	89.0	1,200	180	3.1
1919	4.1	3.4	17.8	99.2	6,000	2,880	49.7
	5.3	4.0	24.8	98.8	6,060	2,930	50.5
	13.2	5.0	61.9	95.0	5,900	2,970	51.2
	13.7	5.0	63.8	93.9	6,120	3,050	52.6
	21.0	6.7	68.3	91.9	5,500	2,900	50.6
	21.6	6.5	69.9	86.4	5,880	3,090	53.3

Table XI shows the annual and average acre yields of Dwarf milo in rows spaced 3½ feet apart in the spacing experiments during the 6-year period from 1914 to 1919, inclusive. In this table the plant spacings which were approximately the same are combined. The first or thickest rate represents a space per plant ranging from 6 to 8 inches; the second has a space of 9 to 10 inches to the plant, and the third has 12 inches of row space to the plant. In the fourth rate the row space ranges from 15 to 18 inches, and in the fifth, from 20 to 24 inches. All rates were not obtained throughout the entire

6-year period. For that reason averages are given for two 4-year periods, a 5-year period, and the 6-year period. In the first four years, from 1914 to 1917, inclusive, the highest average was made by the 15 to 18 inch spacing and the lowest by the 9 to 10 inch spacing. In the four years from 1915 to 1919, omitting 1918, the

FIG. 11.—Dawn (dwarf) kafir in rows spaced 84 inches apart, plants spaced 6 inches apart, Amarillo Cereal Field Station, Amarillo, Tex., August 17, 1915.

20 to 24 inch spacing ranks first, while the 6 to 8 inch spacing is lowest in yield. In the 5-year period from 1914 to 1918, inclusive, which includes only three rates for all years, the averages are approximately the same. In the 6-year period the averages are approximately the same for the two rates which are represented in all years.

TABLE XI.—*Annual and average yields of Dwarf milo in rows spaced 3½ feet apart in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Row space per plant.	Annual yields per acre.						Average yields per acre.			
	1914	1915	1916	1917	1918	1919	4 years, 1914 to 1917.	4 years, 1915, 1916, 1917, and 1919.	5 years, 1914 to 1918.	6 years, 1914 to 1919.
	Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
6 to 8 inches	26.2	67.2	7.4	27.6	1.7	50.5	32.1	38.2	26.0	30.1
9 to 10 inches	25.3	68.1	7.6	26.2	4.7	.....	31.8	.....	26.4	.....
12 inches	14.8	72.8	15.5	27.3	3.3	51.2	32.6	41.7	26.7	30.8
15 to 18 inches	20.5	61.5	18.3	34.5	.....	52.6	33.7	41.7	.....	.....
20 to 24 inches	.....	69.8	19.3	28.1	.....	50.6	.....	42.0	.....	.....

SECOND SECTION, ROWS 7 FEET APART.

The second section of these experiments differs from the first section in the spacing of the rows, which are 7 feet apart, and of the plants, which are twice as thick in the rows.

Table XII shows the data recorded for Dwarf milo grown in rows spaced 7 feet apart in the spacing experiments during the 6-year period from 1914 to 1919, inclusive. Six plats were grown each year, representing as many rates of seeding. However, the spacings are not in all cases the same in all years.

TABLE XII.—*Data recorded in the spacing experiments with Dwarf milo grown in rows spaced 7 feet apart at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Year.	Row space.		Suckers.	Erect heads.	Yields per acre.		
	Plants.	Stalks.			Total crop.	Grain.	
	Inches.	*Inches.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Bushels.*
1914	3.7	2.6	30.0	99.8	4,240	1,870	32.2
	3.9	2.8	29.3	99.9	3,820	1,250	21.6
	3.9	2.6	33.2	99.4	4,660	1,700	29.3
	4.3	2.8	34.6	99.6	5,020	1,820	31.4
	5.7	2.6	54.6	99.7	4,800	1,870	32.2
	8.6	3.0	65.0	99.7	5,140	2,060	35.5
1915	4.1	2.6	37.5	90.4	7,680	3,270	56.4
	4.5	2.6	43.3	92.4	7,730	3,520	60.7
	6.0	2.8	52.9	91.9	7,540	3,520	60.7
	9.0	3.7	58.4	84.3	7,260	3,130	54.0
	9.4	3.9	58.5	72.9	7,340	3,080	53.1
	11.2	4.4	60.3	66.0	7,370	2,980	51.4
1916	2.1	1.8	13.4	100.0	1,590	520	9.0
	3.9	3.2	18.0	99.9	1,230	400	6.9
	5.2	3.6	30.1	97.4	1,790	710	12.3
	5.9	3.5	40.0	99.4	2,500	900	15.5
	7.5	4.0	47.1	98.6	3,500	1,620	27.5
	26.4	15.3	42.1	87.1	1,420	730	12.6
1917	3.1	2.9	8.9	96.6	3,600	1,600	27.6
	4.5	3.4	23.6	95.3	4,508	1,850	31.9
	6.0	3.8	36.5	94.4	5,120	2,060	35.5
	7.4	3.5	53.2	92.2	4,920	1,870	32.2
	9.1	3.4	62.3	92.8	5,120	1,890	32.6
	12.2	3.9	68.1	92.7	4,800	1,780	30.7
1918	1.5	1.5	0	99.5	1,160	170	2.9
	2.5	2.4	4.7	97.9	1,060	230	4.0
	3.0	2.7	9.9	98.5	1,120	260	4.5
	4.5	3.7	16.9	97.2	1,860	700	12.1
	6.0	5.1	16.0	96.0	960	230	4.0
	12.7	7.8	38.7	87.8	900	270	4.7
1919	2.7	2.5	7.9	94.8	5,100	2,720	46.9
	2.7	2.6	6.3	96.4	5,000	2,680	46.2
	6.5	3.6	45.4	88.7	5,160	2,830	48.9
	10.3	4.6	55.5	86.0	4,900	2,660	45.9
	16.0	5.5	64.7	80.2	4,300	2,320	40.0
	22.6	7.1	68.8	72.3	3,400	1,780	30.7

In 1914 the thickest rate averaged one plant to 3.7 inches and the thinnest rate one plant to 8.6 inches of row space, with four intermediate rates ranging from 3.9 to 5.7 inches of row space to the plant. In 1915 the thick rate was one plant to 4.1 inches of row space and the thin rate had a row space of 11.2 inches to the

plant. The four intermediate rates ranged from 4.5 to 9.4 inches to the plant. In 1916 the first five rates ranged from 2.1 to 7.5 inches of row space to the plant in the different rates. The sixth rate was abnormally thin, averaging 26.4 inches of row space to the plant. In 1917 the rates ranged from 3.1 to 12.2 inches of row space to the plant. In 1918 the thick rate had 1.5 inches of row space to the plant and the thin rate 12.7 inches, with the four intermediate rates ranging from 2.5 to 6 inches of row space to the plant. In 1919 there were only five rates, the first two plats having the same stand. The thick rate had a stand of one plant to 2.7 inches of row space, while the thin rate was abnormally thin, averaging one plant to 22.6 inches of row space. In the three intermediate rates the row space to the plant ranged from 6.5 to 16 inches.

The average stalk space in the different rates does not show the wide range that the plant space does. This is due to the difference in the number of suckers produced, the thin rates having the larger number. The percentage of suckers varies from year to year, but usually increases as the stand decreases.

The percentage of erect heads ran high in most plats in all the years. Thin stands have a tendency to produce pendent heads, though conditions during heading time influence their production.

The total crop yield ranges from 7,730 pounds from the rate with 4.5 inches of row space to the plant in the favorable season of 1915, to 900 pounds from the 12.7-inch rate in 1918. It varies greatly from the different rates in the same year, and from the same rates in different years. In the favorable seasons of 1915 and 1919, the thicker rates produced best, while in the less favorable seasons of 1914, 1916, and 1917 the thinner rates yielded highest. The high grain yields can not always be correlated with high total crop yields. This may be due in part to the development of suckers. A production of suckers which do not develop heads may increase the total crop yields, but the percentage of grain may then be less than in cases having fewer suckers and a higher percentage of stalks bearing heads. To determine the best rate of seeding it is necessary to study averages which cover a series of years. These are shown in Table XIII.

The annual and average acre yields of Dwarf milo in rows spaced 7 feet apart are shown in Table XIII. Four rates are here represented. In the first or thick rate, the space per plant ranges from 2 to 3 inches in the different years; in the second rate, from 4 to 4½ inches; in the third rate it is approximately 6 inches; and in the fourth it ranges from 8 to 12 inches.

Seasonal conditions play an important part in the grain yields. In the four years from 1914 to 1917, which include one fair, one good, and two poor seasons, the average is in favor of the thin rate. In the

four years, 1915, 1916, 1917, and 1919, which include two good and two poor seasons, the average is slightly in favor of the 6-inch rate. The 5-year period, 1914 to 1918, which includes one fair, one good, and three poor seasons, shows the higher yields from the thin rates. The 6-year period adds another good season to the 5-year period, but does not materially change the results, which indicate that in rows spaced 7 feet apart, somewhere between 6 and 12 inches of row space per plant for Dwarf milo is the surest rate under Amarillo conditions.

TABLE XIII.—*Annual and average yields of Dwarf milo in rows spaced 7 feet apart in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period, from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.]

Row space per plant.	Annual yields per acre.						Average yields per acre.			
	1914	1915	1916	1917	1918	1919	4 years, 1914 to 1917.	4 years, 1915, 1916, 1917, and 1919.	5 years, 1914 to 1918.	6 years, 1914 to 1919.
	Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
2 to 3 inches	32.2	56.4	9.0	27.6	4.0	46.9	31.3	35.0	25.8	29.4
4 to 4½ inches	27.4	60.7	6.9	31.9	12.1	27.8	31.7	31.8	27.8	27.8
6 inches	32.2	60.7	15.5	35.5	4.0	48.9	36.0	40.2	29.6	32.8
8 to 12 inches	35.5	53.1	27.5	32.6	4.7	45.9	37.2	39.8	30.7	33.2

COMPARATIVE YIELDS FROM 3½-FOOT AND 7-FOOT ROWS.

Table XIV shows the annual and average acre yields of Dwarf milo in the spacing experiments, arranged so that comparisons may be made easily between the different methods. Four different rates are represented, and these are arranged in four groups, each containing the yields from rows spaced 3½ and 7 feet apart, but having the same number of plants to the acre. The data shown are the distance between the rows in feet, the row space between plants in inches, and the annual and average acre yields for each spacing.

Group A contains the data for the thick rate, with an average of approximately one plant to 6½ inches of row space in rows 3½ feet apart, and of one plant to each 3 inches where the rows were 7 feet apart, or about 24,000 plants to the acre. The highest yield, 67.2 bushels, from this rate was made in 1915, with the rows spaced 3½ feet apart. This method also made the lowest yield, 1.7 bushels, in 1918, but it has given the highest average in the 4-year, 5-year, and 6-year periods.

Group B represents an average stand of one plant to 9½ inches of row space where the rows are 3½ feet apart, and 4.3 inches where the rows are 7 feet apart, or approximately 16,000 plants to the acre. This rate occurs in only five years where the rows are spaced 3½

feet apart. A higher yield was produced from 3½-foot rows than from 7-foot rows during only two of these five years. The average yield from both methods in the 4-year period is the same, but in the 5-year period the average is in favor of the rows spaced 7 feet apart.

TABLE XIV.—*Annual and average yields of Dwarf milo in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 58 pounds.

Approximate number of plants per acre.	Space between rows.	Row space per plant.	Annual yields per acre.						Average yields per acre.		
			1914	1915	1916	1917	1918	1919	4 years, 1914 to 1917.	5 years, 1914 to 1918.	6 years, 1914 to 1919.
	Feet.	*Inches.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Group A, 24,000 plants.	3½	6.5	26.2	67.2	7.4	27.6	1.7	50.5	32.1	26.0	30.1
	7	3.0	32.2	56.4	9.0	27.6	4.0	46.9	31.3	25.8	29.4
Group B, 16,000 plants.	3½	9.5	25.3	68.1	7.6	26.2	4.7	.....	31.8	26.4	.....
	7	4.3	27.4	60.7	6.9	31.9	12.1	27.8	31.7	27.8	27.8
Group C, 13,000 plants.	3½	12.0	14.8	72.8	15.5	27.3	3.3	51.2	32.6	26.7	30.8
	7	6.0	32.2	60.7	15.5	35.5	4.0	48.9	36.0	29.6	32.8
Group D, 9,000 plants.	3½	16.5	20.5	61.5	18.3	34.5	.....	52.6	33.7	.....	.....
	7	9.6	35.5	53.1	27.5	32.6	4.7	45.9	37.2	.....	33.2

Group C represents a stand of 12 inches of row space to the plant in the rows spaced 3½ feet apart and 6 inches in the rows 7 feet apart, or approximately 13,000 plants to the acre. At this rate the best yields were produced in two years from the rows spaced 3½ feet apart and in three years from the rows spaced 7 feet apart, while the methods tied in yield in the other year. The rows spaced 7 feet apart lead in average yields in all three periods.

Group D has an average of one plant to 16½ inches of row space in rows spaced 3½ feet apart and 9.6 inches where the rows are spaced 7 feet apart, or approximately 9,000 plants to the acre. This rate is not represented in 1918 by the method with the rows spaced 3½ feet apart, which leaves five years only for comparison between the two methods. In this period the 3½-foot rows produced the highest yield in three years, but in the 5-year period the rows spaced 7 feet apart produced a higher average yield by 3½ bushels. It is interesting to note that the method of spacing the rows 7 feet apart usually produced the highest yields in fair to poor seasons, which is an indication that it is the surest method of growing a grain crop in unfavorable seasons.

DAWN KAFIR.

The series of spacing experiments conducted with Dwarf milo were duplicated with Dawn kafir (figs. 10 and 11). As the nature of the experiment has already been described, only the results obtained

need to be considered. These data are shown in Tables XV to XIX, inclusive.

FIRST SECTION, ROWS 3½ FEET APART.

Table XV shows the results with Dawn kafir in the spacing experiment with the rows 3½ feet apart. (Fig. 10.) Six plats were sown each year, representing six different rates. In a few cases practically the same stands were obtained in two plats in the same year. This condition occurred in the first two plats in 1914 and again in the last two plats in 1918. In general the thick rate ranged from 3 to 7 inches and the thin rate from 15 to 20 inches of row space to the plant in the different years. However, the last two plats in 1917 and in 1919 had much thinner stands.

TABLE XV.—*Data recorded in the spacing experiments with Dawn kafir grown in rows spaced 3½ feet apart at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Year.	Row space—		Suckers.	Headed.	Yields per acre.		
	Plants.	Stalks.			Total crop.	Grain.	
	Inches.	*Inches.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Bushels.*
1914	7.0	5.3	24.8	40.7	4,222	522	8.7
	7.2	5.0	30.7	63.0	5,180	1,052	17.5
	8.0	5.2	35.3	67.1	5,360	1,110	18.5
	10.8	5.6	47.7	59.8	4,780	1,010	16.8
	11.0	5.9	46.7	60.4	4,860	1,120	18.7
	18.7	7.7	58.7	76.2	4,600	1,140	19.0
1915	6.0	4.1	32.7	93.6	11,710	3,610	60.2
	8.8	4.1	53.3	93.3	11,410	4,140	69.0
	11.8	4.9	58.6	95.3	11,130	4,100	68.3
	14.8	5.4	63.5	96.6	11,250	4,070	67.8
	18.8	6.5	65.3	96.0	9,870	3,760	62.7
	21.1	8.0	62.0	96.1	8,470	3,330	55.5
1916	4.0	3.4	16.0	8.9	1,160	0	.....
	7.4	4.7	36.3	13.3	1,640	60	1.0
	11.8	6.2	47.7	59.6	3,800	350	5.80
	13.0	6.5	50.5	53.6	3,000	250	4.2
	17.1	7.4	56.6	51.3	2,780	230	3.8
	20.5	8.6	58.3	62.7	2,640	310	5.2
1917	6.1	4.0	34.4	67.2	6,880	890	14.8
	10.8	4.9	54.5	64.5	6,120	730	12.2
	15.9	5.5	64.9	68.2	6,260	1,110	18.5
	19.3	5.9	69.7	73.5	5,940	1,070	17.8
	26.2	7.8	70.1	90.5	5,940	1,610	26.8
	32.7	8.9	72.7	83.8	5,160	1,260	21.0
1918	3.0	2.3	25.1	2.1	1,660	20	.3
	6.0	5.2	14.2	6.0	1,540	40	.7
	9.0	7.7	14.1	18.9	1,580	110	1.8
	12.0	10.0	17.0	12.1	1,080	40	.7
	14.6	11.6	20.6	22.1	1,160	70	1.2
	14.9	10.8	27.1	23.0	1,400	200	3.3
1919	7.6	4.3	15.4	100	6,840	2,330	38.8
	13.0	6.7	48.3	100	5,860	1,940	32.3
	19.6	9.6	51.2	100	5,700	1,970	32.8
	21.9	10.9	50.0	100	5,160	1,780	29.7
	37.4	16.4	55.1	100	4,160	1,530	25.5
	38.7	15.2	60.7	100	4,300	1,560	26.0

The tendency to produce suckers changed with the stand and with the season, the percentages usually increasing as the stands decreased. In 1915 the proportion of suckers ranged from 32.7 per cent in the

6-inch spacing to 65.3 per cent in the 18-inch spacing. The maximum, 72.7 per cent, was produced in 1917 from a stand of 32.7 inches of row space to the plant. A low percentage of suckers was produced by all rates of seeding in 1918.

The number of stalks bearing heads varies widely between the spacings in some seasons. The number or percentage of headed stalks usually increases as the stands decrease. This is especially true for the poor seasons of 1916, 1917, and 1918.

The best total crop yields were produced in 1915, and the poorest in 1918. The highest yield, 11,710 pounds, was from the 6-inch spacing in 1915, and the lowest, 1,080 pounds, from the 12-inch spacing in 1918. The highest grain yield does not always accompany the highest total crop yield. Seasonal conditions at and following heading largely govern the grain yield. Favorable seasons are conducive to high grain yields from thick stands, while thin stands have the advantage in unfavorable seasons. In the favorable season of 1915 the highest grain yield was from a stand having 8.8 inches of row space to the plant. In the poor seasons of 1916, 1917, and 1918 the highest yields were produced by stands with 6 to 7 inches of row space to the plant. A study of the average yields for a series of years is essential to determine the rate which will give the best results under average conditions. These are presented in Table XVI.

TABLE XVI.—*Annual and average yields of Dawn kafir in rows spaced 3½ feet apart in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Row space per plant.	Yields per acre.						Average yields per acre.				
	1914	1915	1916	1917	1918	1919	3 years, 1915, 1917, and 1919.	4 years, 1915 to 1918.	5 years, 1914, 1915, and 1917 to 1919.	5 years, 1914 to 1916, 1918, 1919.	6 years, 1914 to 1919.
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
6 to 7 inches	8.7	60.2	1.0	14.8	0.7	38.8	37.9	19.2	24.6	21.9	20.7
8 to 10 inches	18.5	69.0	.....	12.2	1.8	25.4	35.5	.....	25.4	.....	.....
11 to 13 inches	18.7	68.3	5.8	.....	.7	32.3	.....	.....	.....	25.2	.....
15 to 19 inches	19.0	62.7	3.8	17.8	3.3	32.8	37.8	21.9	27.1	24.3	23.2
21 to 26 inches	.....	55.5	.....	26.8	.....	29.7	37.3	.....	.....	.....	.....

The annual and average acre yields from the six spacings are shown in Table XVI. The first or thick rate has a stand in the different years with 6 to 7 inches of row space to the plant. The second rate has a stand with 8 to 10 inches of row space to the plant. This rate is omitted in 1916, and the 11 to 12 inch stand is missing in 1917. The 15 to 19 inch stand continued through the 6-year period, but the 21 to 26 inch stand obtains only in three years. In order to get comparisons of all rates it is necessary to strike averages for a 3-year, a 4-year, two 5-year, and a 6-year period. In the 3-year average,

which includes two good seasons and one poor one, there is practically no difference in the average yields from the first, fourth, and fifth rates. In the 4-year period, which includes two rates only, the average yield is in favor of the 15 to 19 inch spacing. This same rate leads in the first 5-year period, but is exceeded by the 11 to 13 inch spacing in the second 5-year period. In the 6-year average, which includes only two rates, the 15 to 19 inch spacing again has first place. These results indicate that under such conditions a stand with about 15 inches of row space to the plant is probably the safest rate.

TABLE XVII.—*Data recorded in the spacing experiments with Dawn kafir grown in rows spaced 7 feet apart at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Year.	Row space.		Suckers.	Headed.	Yields per acre.		
	Plants.	Stalks.			Total crop.	Grain.	
	Inches.	*Inches.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Bushels.*
1914	5.8	4.6	21.0	96.8	4,300	1,500	25.0
	6.6	4.6	31.1	88.4	4,120	1,410	23.5
	6.7	4.9	26.5	86.5	3,480	1,140	10.0
	7.7	5.2	32.1	92.7	3,600	1,170	19.5
	8.5	5.8	31.3	92.7	3,320	1,090	18.2
	8.8	4.9	44.5	86.9	4,140	1,490	24.8
1915	3.0	2.6	11.5	96.6	8,500	2,860	47.7
	4.4	3.0	32.6	92.7	8,170	2,880	48.0
	5.9	3.4	43.0	93.3	8,290	2,980	49.7
	7.5	4.4	40.5	90.5	7,370	2,830	47.2
	9.5	4.9	48.2	93.9	6,770	2,630	43.8
	10.4	5.1	51.2	97.5	6,450	2,450	40.8
1916	2.0	1.9	9.2	19.7	1,660	100	1.7
	3.9	2.6	31.2	54.1	3,360	510	8.5
	6.0	4.0	33.4	79.5	3,120	640	10.7
	8.6	5.1	40.3	60.8	1,920	320	5.3
	13.0	6.6	50.0	72.6	1,940	370	6.2
	20.5	9.2	55.3	89.3	2,440	650	10.8
1917	3.3	2.8	14.7	86.4	4,640	1,060	17.7
	4.7	3.1	35.0	82.1	5,020	1,300	21.7
	7.8	3.8	51.2	85.5	5,700	2,030	33.8
	12.7	4.8	62.3	89.8	4,840	1,530	25.5
	15.8	5.4	65.7	90.8	4,420	1,400	23.3
	32.9	9.3	65.7	94.2	3,480	1,220	20.3
1918	1.5	1.5	0.0	15.4	1,440	120	2.0
	3.0	2.9	3.3	18.0	1,060	115	1.9
	4.5	4.2	7.5	36.6	940	180	3.0
	6.0	5.5	9.0	28.0	640	70	1.2
	7.6	6.4	15.5	50.4	900	180	3.0
	15.6	11.6	26.1	66.5	1,240	70	1.2
1919	4.3	3.0	29.5	100	6,400	2,225	37.1
	5.9	4.4	24.7	100	5,225	1,888	31.5
	9.5	6.3	33.8	100	4,600	1,640	27.3
	12.3	7.8	36.5	100	4,020	1,420	23.7
	21.0	9.9	52.6	100	3,340	1,200	20.0
	47.1	18.7	60.2	100	2,000	713	11.9

SECOND SECTION, ROWS 7 FEET APART.

Table XVII shows the data recorded with Dawn kafir in rows spaced 7 feet apart (fig. 11) in the spacing experiments. In this

section, as in the first, six plats were seeded each year, representing as many different rates. The stands obtained from the same rate were not the same in all years. The stands in the thick rate range from about 2 to 5 inches of row space to the plant in the different years, while the thinner stands in some years have a much wider range.

The various spacings between plants in rows 7 feet apart have an influence on suckering similar to those in rows 3½ feet apart, the percentage increasing as the stand decreases. In 1918 the thick stand produced no suckers, but the percentage increased in the thinner rates up to 26 per cent in the 15-inch stand. The percentage of suckers was much higher in other years, but it usually showed the same general trend between the thin and thick rates.

The good seasons show a high percentage of stalks bearing heads, but in these seasons, as in the poor ones, the thinner plantings show a higher percentage than the thicker ones. The lowest percentage in all the rates was produced in 1918 and the highest in 1919.

The total crop yields in the 7-foot rows do not run as high as in the corresponding spacings with the rows spaced 3½ feet apart. The highest total crop yield, 8,500 pounds, in this 6-year period, was made by the 3-inch spacing in 1915, and the lowest by the 6-inch spacing in 1918. The high grain yields do not in all cases follow the high total crop yields. In 1915 the spacing that ranked second in total crop yield had first place in grain yield. In 1916 and 1918 the spacings given third place in total crop yield took first place in grain yields. The grain yields were higher from all rates in 1915 than in any other year.

TABLE XVIII.—*Annual and average yields of Dawn kafir in rows spaced 7 feet apart in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Row space per plant.	Annual yields per acre.						Average yields per acre.			
	1914	1915	1916	1917	1918	1919	4 years, 1915 to 1918.	5 years, 1914 to 1916, 1918, 1919.	5 years, 1915 to 1919.	6 years, 1914 to 1919.
	Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
2 to 3 inches	.....	47.7	1.7	17.7	1.9	.....	17.3	.....	.....	.....
4 to 5 inches	25.0	48.0	8.5	21.7	3.0	37.1	20.3	24.3	23.7	23.9
6 inches	23.5	49.7	10.7	.....	1.2	31.5	.....	23.3	.....	.....
8 to 9 inches	18.2	43.8	5.3	33.8	3.0	27.3	21.5	19.5	22.6	21.9
10 to 15 inches	.....	40.8	6.2	25.5	1.2	23.7	18.4	.....	19.5	.....

Table XVIII shows the annual and average acre yields in bushels of 60 pounds each for five rates in part or all of the 6-year period from 1914 to 1919, inclusive. The thick rate had a stand ranging from 2 to 3 inches of row space to the plant in the four years for which data are shown. The second rate, with 4 to 5 inches of row space to the

plant, was obtained each year. The 6-inch rate is missing in 1918, and the 10 to 15 inch rate was omitted in 1914. In the 4-year period, which includes four rates, the average is in favor of the 8 to 9 inch rate, but in the two 5-year periods and one 6-year period it favors the 6-inch rate. This indicates that 6 inches of row space to the plant in rows spaced 7 feet apart is probably the best rate.

COMPARATIVE YIELDS FROM 3½-FOOT AND 7-FOOT ROWS.

Table XIX shows the annual and average acre yields of Dawn kafir in 3½-foot and in 7-foot rows in the spacing experiments, so that comparisons between the spacings may be easily made.

TABLE XIX.—*Annual and average yields of Dawn kafir in the spacing experiments at the Amarillo Cereal Field Station during the 6-year period from 1914 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds.]

Approximate number of plants per acre.	Space between rows.	Row space per plant.	Annual yields per acre.						Average yields per acre.					
			1914	1915	1916	1917	1918	1919	3 years, 1915, 1917, and 1919.	4 years, 1915 to 1918.	5 years, 1914 to 1916, 1918, 1919.	5 years, 1914, 1915, 1917 to 1919.	5 years, 1915 to 1919.	6 years, 1914 to 1919.
	Feet.	*Inches.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Group A, 24,000 plants	3½	6–7	8.7	60.2	1.0	14.8	0.7	38.8	37.9	19.2	21.9	24.6	23.1	20.7
	7	2–3	.....	47.7	1.7	17.7	1.9	.....	.....	17.3	.....	.....	.....	.....
Group B, 18,000 plants	3½	8–10	18.5	69.0	.....	12.2	1.8	25.4	35.5	.....	.....	25.4	.....	.....
	7	4–5	25.0	48.0	8.5	21.7	3.0	37.1	35.6	20.3	24.3	27.0	23.7	23.9
Group C, 12,500 plants	3½	11–13	18.7	68.3	5.8	.....	.7	32.3	.....	.....	25.2	.....	.....	.....
	7	6	23.5	49.7	10.7	.....	1.2	31.5	.....	.....	23.3	.....	.....	.....
Group D, 9,000 plants	3½	15–19	19.0	62.7	3.8	17.8	3.3	32.8	37.8	21.9	24.3	27.1	24 1	23.2
	7	8–9	18.2	43.8	5.3	33.8	3.0	27.3	37.7	21.5	19.5	25.2	22.6	21.9
Group E, 7,000 plants	3½	21–26	.....	55.5	.....	26.8	.....	29.7	37.3	.....	.....	.....	.....	.....
	7	10–15	.....	40.8	6.2	25.5	1.2	23.7	30.0	18.4	.....	.....	19.5	.....

Group A represents a rate of 6 to 7 inches of row space to the plant in rows 3½ feet apart and 2 to 3 inches where the rows are 7 feet apart, or an average of approximately 24,000 plants to the acre. At this rate the methods are comparable in only four years, and in that period the average yield is in favor of the rows 3½ feet apart.

Group B has a stand of 8 to 10 inches in rows 3½ feet apart and its equivalent in rows 7 feet apart, or approximately 18,000 plants to the acre. This rate shows a small difference in the average yields in favor of rows spaced 7 feet apart in the 3-year and the 5-year periods for which averages are possible.

Group C has a plant space of 11 to 13 inches in rows spaced 3½ feet apart and of 6 inches in rows spaced 7 feet apart, or an average of approximately 12,500 plants to the acre. These rates were obtained in only five years and in that period the average yield is in favor of the rows spaced 3½ feet apart.

Group D represents a stand of 15 to 19 inches of row space to the plant where the rows are spaced 3½ feet apart, and 8 to 9 inches with

the rows spaced 7 feet apart, or approximately 9,000 plants to the acre. This rate continued through the 6-year period from 1914 to 1919, inclusive. Averages are made for a 3-year period, a 4-year period, three 5-year periods, and a 6-year period. The average yields are approximately the same for both methods in the 3-year and 4-year periods. In the three 5-year periods and the 6-year period the average yields are in favor of rows 3½ feet apart.

Group E shows a stand of 21 to 26 inches of row space to the plant in rows spaced 3½ feet apart and 10 to 15 inches where the rows are spaced 7 feet apart, or an average of approximately 7,000 plants to the acre. This rate was obtained in three years in the 3½-foot rows and in five years in the 7-foot rows. The average yield for this rate in the three years 1915, 1917, and 1919 is decidedly in favor of the rows spaced 3½ feet apart.

These data show that in favorable seasons, such as 1915 and 1919, the rows spaced 3½ feet apart produced a higher yield in all rates with one exception than where the rows were 7 feet apart; but in the poor seasons of 1916, 1917, and 1918 the high yields are from the 7-foot rows in practically all cases. This tends to show that the method with rows spaced 7 feet apart is a surer way to grow a grain crop in localities which are likely to have unfavorable seasons. The 6-year average yields indicate that a row space of 8 to 9 inches to the plant is the best rate when the rows are spaced 7 feet apart.

ENVIRONMENTAL EXPERIMENTS.

Environmental experiments were conducted at the Cereal Field Station, Amarillo, Tex., at the Plant Introduction Field Station, Chico, Calif., and at Arlington Experimental Farm, Rosslyn, Va., the objects of which were to determine the effect of different climatic conditions on plant growth and on chemical composition and to determine the comparative productivity of home-grown and imported seed.

These experiments included three of the best commercial varieties, viz, Dwarf milo (C. I. No. 332), feterita (C. I. No. 182), and Dawn kafir (C. I. No. 340). In 1913 all varieties were grown at the Cereal Field Station, Amarillo, Tex. Seed from that crop was sent to the other points for sowing in 1914. Beginning with the 1914 crop seed was exchanged between all three points each year for sowing the following season. It was not practicable to get yield data on the crop at either the Plant Introduction Field Station or at the Arlington Experimental Farm, owing to the eating of a large percentage of the immature kernels by birds. The damage from that source at these points was so great that enough seed for chemical analysis and for sowing the next season could be obtained only by protecting a number of the heads with paper bags.

TABLE XX.—*Agronomic data recorded in the environmental experiments with grain sorghums grown at the Amarillo Cereal Field Station during the 5-year period from 1915 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds for kafir and at 58 pounds for other sorghums.]

Year, variety, and source of seed.	Row space.		Suckers.	Erect heads.	Headed.	Yields per acre.		
	Plants.	Stalks.				Total crop.	Grain.	
1915.								
Dwarf milo:	*Inches.*	*Inches.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Bushels.*
Amarillo, Tex.	7.2	3.3	54.1	73.0	.....	10,220	3,580	61.7
Arlington, Va.	7.2	3.3	54.1	80.8	.....	9,180	3,780	65.2
Feterita:								
Amarillo, Tex.	10.6	3.8	64.2	.....	97.4	7,680	2,720	46.9
Arlington, Va.	10.6	3.9	63.4	.....	95.2	10,400	2,820	48.6
Dawn kafir:								
Amarillo, Tex.	8.0	4.6	42.5	.....	100	11,380	3,220	53.7
Arlington, Va.	8.0	4.5	43.3	.....	97.8	11,680	3,500	58.3
1916.								
Dwarf milo:								
Amarillo, Tex.	11.3	5.1	55.1	97.0	.....	1,090	160	2.8
Arlington, Va.	11.3	5.6	50.5	98.9	.....	800	170	2.9
Chico, Calif.	11.3	5.1	55.1	100	.....	760	130	2.3
Feterita:								
Amarillo, Tex.	14.8	6.3	57.3	.....	13.6	1,050	270	4.7
Arlington, Va.	14.7	5.2	64.1	.....	43.2	2,716	916	15.8
Chico, Calif.	14.8	5.5	63.7	.....	46.5	2,370	860	14.8
Dawn kafir:								
Amarillo, Tex.	10.8	4.7	55.9	.....	47.1	3,740	340	5.7
Arlington, Va.	10.7	5.1	52.5	.....	52.7	4,000	370	6.2
Chico, Calif.	10.8	5.3	50.7	.....	50.7	3,460	320	5.3
1917.								
Dwarf milo:								
Amarillo, Tex.	12.5	4.2	66.4	81.6	.....	6,400	1,720	29.7
Arlington, Va.	12.5	4.2	66.4	76.9	.....	5,400	1,560	26.9
Chico, Calif.	12.5	4.0	68.8	96.1	.....	4,840	1,320	22.8
Feterita:								
Amarillo, Tex.	19.4	5.0	74.1	.....	.....	5,750	1,080	18.6
Arlington, Va.	23.6	5.7	75.7	.....	.....	4,640	1,000	17.2
Chico, Calif.	22.9	5.6	82.8	.....	.....	4,000	980	16.9
Dawn kafir:								
Amarillo, Tex.	26.4	7.2	72.8	.....	91.4	7,640	1,400	26.7
Arlington, Va.	26.4	5.6	78.9	.....	83.4	5,240	1,740	29.0
Chico, Calif.	26.4	5.1	80.5	.....	79.8	5,720	1,180	19.7
1918.								
Dwarf milo:								
Amarillo, Tex.	14.8	9.9	32.9	87.3	.....	920	280	4.8
Arlington, Va.	15.0	10.7	29.0	91.5	.....	1,400	380	6.6
Feterita:								
Amarillo, Tex.	10.7	7.1	33.5	.....	71.2	1,240	180	3.1
Arlington, Va.	10.3	7.4	28.2	.....	65.4	840	240	4.1
Dawn kafir:								
Amarillo, Tex.	16.1	12.5	22.1	.....	27.0	1,400	80	1.3
Arlington, Va.	16.2	13.7	15.5	.....	44.3	1,160	120	2.0
1919.								
Dwarf milo:								
Amarillo, Tex.	10.4	4.4	57.6	100	.....	6,000	2,900	50.0
Arlington, Va.	12.9	4.8	62.1	100	.....	5,200	2,700	46.6
Chico, Calif.	8.5	3.9	53.4	100	.....	5,520	2,600	44.3
Feterita:								
Amarillo, Tex.	44.8	10.8	75.3	.....	100	3,760	1,580	27.2
Arlington, Va.	28.6	7.8	73.1	.....	100	4,800	2,040	35.1
Chico, Calif.	13.4	4.3	68.1	.....	100	5,920	2,600	44.8
Dawn kafir:								
Amarillo, Tex.	33.1	11.6	65.2	.....	100	4,400	1,560	26.0
Arlington, Va.	20.1	7.9	60.5	.....	100	5,600	1,860	31.0
Chico, Calif.	10.4	5.0	51.9	.....	100	6,800	2,240	37.3

AGRONOMIC DATA.

Table XX shows the agronomic data recorded for the environmental experiments conducted at the Cereal Field Station, Amarillo, Tex., in the 5-year period from 1915 to 1919, inclusive. In 1915 and again in 1918 no crop from seed from Chico, Calif., was grown. For each variety the data recorded are from seed continuously grown at Amarillo in comparison with that from seed grown at the other points. The stands in all plats of the same variety were made comparable by hand thinning each year except in 1919, which eliminated whatever influence unequal stands might have had on the crop.

The data recorded for suckers and erect heads in Dwarf milo and headed stalks in the other varieties generally do not show any striking differences in the same year. However, in the 1916 crop, feterita from the Amarillo seed is somewhat lower in the percentage of suckers and considerably below the others in percentage of stalks bearing heads.

The yields of the same variety are fairly close in the same year. The seed from the same source did not make the highest yield in all years.

TABLE XXI.—*Annual and average yields of grain sorghums grown in the environmental experiments at the Amarillo Cereal Field Station during the 5-year period from 1915 to 1919, inclusive.*

[In the statement of yields per acre the bushel is rated at 60 pounds for kafir and at 58 pounds for other sorghums.]

Variety and source of seed.	Annual yields per acre.					Average yields per acre.	
	1915	1916	1917	1918	1919	3 years, 1916, 1917, and 1919.	6 years, 1915 to 1919.
Dwarf milo:	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Amarillo, Tex	61.7	2.8	29.7	4.8	50.0	27.5	29.8
Arlington, Va	65.2	2.9	26.9	6.6	46.6	25.5	29.6
Chico, Calif	.....	2.3	22.8	.....	44.8	23.3	.....
Feterita:							
Amarillo, Tex	46.9	4.7	18.6	3.1	27.2	16.8	20.1
Arlington, Va	48.6	15.8	17.2	4.1	35.1	22.7	24.2
Chico, Calif	.....	14.8	16.9	.....	44.8	25.5	.....
Dawn kafir:							
Amarillo, Tex	53.7	5.7	26.7	1.3	26.0	19.5	22.7
Arlington, Va	58.3	6.2	29.0	2.0	31.0	22.1	25.3
Chico, Calif	.....	5.3	19.7	.....	37.3	20.8	.....

The annual and average acre yields recorded in Table XXI show that Dwarf milo from Amarillo seed yielded highest in 1917 and 1919, and from the Arlington seed in 1915, 1916, and 1918. The 3-year average yield favors the home-grown seed, but the 5-year average yield shows no difference between that and the seed grown at the Arlington Experimental Farm.

Feterita made the high yield from home-grown seed in only one year; from seed grown at the Arlington Experimental Farm, Va., in three years; and from seed grown at Chico, Calif., in one year. In the 3-year average yield, plats from Chico seed take first place and from the home-grown seed third place. In the 5-year average yield the plat from home-grown seed is lowest.

Dawn kafir produced less favorable results from home-grown seed than either of the other varieties. It made the best yield each year from seed grown elsewhere. The crop grown from Arlington seed leads in both the 3-year and the 5-year periods.

These data tend to show that the source of the seed has little influence on the yield of the resulting crop when grown at the Amarillo Cereal Field Station.

CHEMICAL COMPOSITION.

Samples of the grain produced in the environmental experiments with Dwarf milo, feterita, and Dawn kafir were analyzed by the Plant Chemical Laboratory of the Bureau of Chemistry. The percentages of water, ash, protein, fat, and fiber were determined, as were the weight of 1,000 kernels and the weight per bushel. Seed grown at Chico, Calif., was not available for sowing at any of the three stations in 1915, while the crop at Chico in 1917 was a total failure, except that enough seed was produced for resowing there in 1918. Analyses are presented from seed grown at the Arlington Experimental Farm, Rosslyn, Va., and at the Cereal Field Station, Amarillo, Tex., from Arlington and Amarillo seed in each of the five years, and at these two stations from Chico seed in 1916, 1917, and 1919. The figures on crops grown at Chico from Arlington and Amarillo seed are for 1915, 1916, 1918, and 1919, and from Chico seed in 1916, 1918, and 1919 only. These data are shown in Table XXII.

In Table XXII the chemical data on environmental experiments are summarized, the data being combined in two ways. The average data shown are first combined by stations at which the crop was grown and then by sources from which the seed was obtained. Thus the average figures on Dwarf milo are given for all the crops grown at the Arlington Experimental Farm, Va., from all three sources, then those grown at Amarillo, Tex., and then those grown at Chico, Calif. Following these, averages are given for all the crops grown at the three stations from seed produced at Arlington, at Amarillo, and at Chico. Similar data are given for feterita and Dawn kafir.

TABLE XXII.—*Average composition and weight of sorghum grains grown in the environmental experiments at three stations in Virginia, Texas, and California, in three or more of the five years from 1915 to 1919, inclusive.*

Crop and place of growth.	Seed from—	Years.	Composition.					Weight.	
			Water.	Ash.	Protein (N. × 6.25).	Fat.	Fiber.	1,000 kernels.	Bushel.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Pounds.*
Dwarf milo:									
Arlington, Va.	Rosslyn, Va.	1915–19	9.71	1.74	10.36	3.00	1.74	36.9	58.0
Do.	Amarillo, Tex.	1915–19	9.61	1.73	10.62	3.06	1.67	33.8	[a] 57.4
Do.	Chico, Calif.	1916–17, 1919	8.77	1.74	10.41	3.03	1.57	34.8	58.8
Amarillo, Tex.	Rosslyn, Va.	1915–19	8.56	1.64	13.45	3.32	1.71	32.0	58.6
Do.	Amarillo, Tex.	1915–19	8.77	1.62	13.39	3.25	1.71	32.0	58.3
Do.	Chico, Calif.	1916–17, 1919	7.81	1.68	13.52	3.72	1.69	33.2	60.3
Chico, Calif.	Rosslyn, Va.	1915–16, 1918–19	8.88	1.61	9.86	3.36	1.62	37.3	59.1
Do.	Amarillo, Tex.	1915–16, 1918–19	9.04	1.56	10.32	3.52	1.61	37.3	59.5
Do.	Chico, Calif.	1916, 1918–19	8.45	1.58	11.75	3.60	1.85	37.4	59.2
Feterita:									
Arlington, Va.	Rosslyn, Va.	1915–19	10.03	1.63	11.30	2.94	1.48	41.3	59.2
Do.	Amarillo, Tex.	1915–19	9.63	1.64	11.13	2.89	1.40	40.9	57.9
Do.	Chico, Calif.	1916–17, 1919	8.78	1.60	10.63	2.82	1.45	40.8	59.2
Amarillo, Tex.	Rosslyn, Va.	1915–19	8.93	1.63	14.32	3.09	1.67	35.3	[a] 56.6
Do.	Amarillo, Tex.	1915–19	8.81	1.65	14.35	3.10	1.74	34.7	[a] 56.2
Do.	Chico, Calif.	1916–17, 1919	8.30	1.55	14.35	3.20	1.64	36.8	58.0
Chico, Calif.	Rosslyn, Va.	1915–16, 1918–19	9.43	1.55	10.73	3.17	1.49	38.3	58.9
Do.	Amarillo, Tex.	1915–16, 1918–19	8.83	1.55	11.34	3.30	1.50	40.6	59.2
Do.	Chico, Calif.	1916, 1918–19	8.89	1.60	11.55	3.38	1.77	35.6	58.3
Dawn kafir:									
Arlington, Va.	Rosslyn, Va.	1915–19	9.68	1.57	11.25	3.38	1.53	22.6	[a] 60.7
Do.	Amarillo, Tex.	1915–19	9.93	1.59	10.92	3.25	1.55	22.9	60.3
Do.	Chico, Calif.	1916–17, 1919	9.00	1.61	10.60	3.45	1.61	22.0	60.8
Amarillo, Tex.	Rosslyn, Va.	1915–19	9.06	1.72	12.92	3.36	1.82	18.9	[a] 58.8
Do.	Amarillo, Tex.	1915–19	8.59	1.81	13.15	3.35	1.83	19.1	58.4
Do.	Chico, Calif.	1916–17, 1919	8.22	1.74	13.33	3.48	1.92	17.9	[a] 56.6
Chico, Calif.	Rosslyn, Va.	1915–16, 1918–19	8.83	1.64	10.89	3.52	1.68	20.0	59.4
Do.	Amarillo, Tex.	1915–16, 1918–19	9.23	1.56	10.83	3.35	1.69	20.9	59.9
Do.	Chico, Calif.	1916, 1918–19	9.01	1.54	11.27	3.66	1.79	20.5	58.7

SUMMARY.

Dwarf milo:									
Rosslyn, Va.	3 stations	13	9.46	1.73	10.47	3.03	1.67	35.2	[b] 57.7
Amarillo, Tex.	do	13	8.47	1.64	13.45	3.39	1.71	32.3	58.9
Chico, Calif.	do	11	8.82	1.59	10.54	3.48	1.68	37.3	59.3
3 stations	Rosslyn, Va.	14	9.06	1.67	11.32	3.22	1.70	35.3	58.4
Do.	Amarillo, Tex.	14	9.15	1.64	11.53	3.26	1.67	34.2	[b] 58.4
Do.	Chico, Calif.	9	8.34	1.66	11.90	3.45	1.70	35.1	59.4
Feterita:									
Rosslyn, Va.	3 stations	13	9.58	1.63	11.08	2.89	1.44	41.0	58.7
Amarillo, Tex.	do	13	8.74	1.62	14.34	3.12	1.69	35.4	[b] 56.8
Chico, Calif.	do	11	9.06	1.57	11.18	3.27	1.57	38.4	58.8
3 stations	Rosslyn, Va.	14	9.47	1.61	12.22	3.06	1.55	38.3	[c] 58.3
Do.	Amarillo, Tex.	14	9.11	1.62	12.34	3.08	1.55	38.6	[c] 57.8
Do.	Chico, Calif.	9	8.66	1.58	12.18	3.13	1.62	37.7	58.5
Dawn kafir:									
Rosslyn, Va.	3 stations	13	9.62	1.59	10.97	3.35	1.56	22.6	[c] 60.6
Amarillo, Tex.	do	13	8.69	1.76	13.10	3.38	1.85	18.7	[d] 58.2
Chico, Calif.	do	11	9.02	1.58	10.97	3.50	1.71	20.5	59.4
3 stations	Rosslyn, Va.	14	9.22	1.64	11.74	3.41	1.68	20.5	[c] 59.6
Do.	Amarillo, Tex.	14	9.25	1.66	11.69	3.31	1.69	21.0	59.5
Do.	Chico, Calif.	9	8.74	1.63	11.73	3.53	1.77	20.1	[e] 59.0

[a] Data for 1917 not included. [b] Twelve years only. [c] Thirteen years only. [d] Eleven years only. [e] Eight years only.

Table XXII shows that the conditions under which the crop is grown have much more effect on its composition than the source from which the seed is obtained. For instance, Dwarf milo grown at the Arlington Experimental Farm, Rosslyn, Va., during the five years from 1915 to 1919, inclusive, shows only very slight variation in chemical composition from seed produced the previous year at Arlington and at Amarillo. Results are available from crops grown at Arlington from Chico seed in only three of the five years, and this naturally causes some variation from the averages of the crops grown from Arlington and Amarillo seed, but in general the composition is practically the same. In the same way milo grown at Amarillo from seed from each of the three points is very similar in composition, but is lower in water content and in ash and considerably higher in protein and fat than milo grown from the same seed at Arlington. Milo grown at Chico from seed from the three sources shows rather more variation than that grown at Arlington and Amarillo. The grain grown at Chico shows a slightly higher water content than that grown at Amarillo, but considerably less than that grown at Arlington. The ash and protein content of the Chico milo is less than that grown at Arlington and decidedly less than that grown at Amarillo. Milo grown at Chico has about the same percentage of fat as that grown at Amarillo and is slightly lower in fiber.

In general, the same observations may be made with regard to feterita and Dawn kafir grown at the three stations. The variation between crops grown from the same seed at the three stations is greater than that between crops grown at any one of the stations from seed from the three sources. The moisture content of the seed grown at Chico is intermediate between that grown at Amarillo and at Arlington. The Amarillo seed is materially higher in protein in each case, and is also higher in fiber. The variations in ash and fat are not marked.

SUMMARY.

The data on the date of seeding, spacing, and environmental experiments with grain sorghums, as presented in this bulletin, may be summarized briefly as follows:

(1) The yields are influenced by seasonal conditions to such an extent that no one date of seeding is best for all years. The average yield in a series of years is the one safe basis for practice.

(2) All the varieties did not give the highest average yield from the same date of seeding. Some yield better from early seeding than others.

(3) Dwarf milo produced the best average yields from sowing on the normal date, about May 23; Dawn kafir from the early date, May 10; and feterita and Manchu kaoliang from the late date, about June 10.

(4) In the 6-year period from 1914 to 1919, inclusive, Dwarf milo in rows spaced 3½ feet apart, made the highest average yield, 30.8 bushels, with 12 inches of row space to the plant. In rows spaced 7 feet apart during this same period, the highest average yield, 33.2 bushels, was made by the plants spaced from 8 to 12 inches apart in the row.

(5) The rows spaced 7 feet apart with 6 inches of row space to the plant averaged 32.8 bushels per acre in this 6-year period, which is 2 bushels more than was made by the corresponding rate in rows spaced 3½ feet apart, and practically the same average yield as obtained from the 8 to 12-inch spacing.

(6) Spacing the rows 7 feet apart is a slightly surer way to grow a grain crop than spacing them 3½ feet apart, but the latter method will produce a higher average total crop yield.

(7) Dawn kafir produces the highest average yields from plants with 15 to 19 inches of row space in rows spaced 3½ feet apart, and from plants with 4 to 5 inches of row space where the rows are spaced 7 feet apart. The 6-year average yields from these rates were 23.2 and 23.9 bushels, respectively.

(8) Dwarf milo seed grown at the Arlington Experimental Farm, Va., produced as high yields and a crop otherwise as good at Amarillo, Tex., as home-grown seed.

(9) Feterita seed grown at the Arlington Experimental Farm, Va., and sent to Amarillo, Tex., averaged 4 bushels more than the home-grown seed in the 6-year period from 1914 to 1919, inclusive, and Dawn kafir from the same source averaged 2.6 bushels higher in this same period.

(10) The yield data presented from all the experiments show conclusively that Dwarf milo is by far the better variety to grow under conditions such as those at the Cereal Field Station, Amarillo, Tex.

(11) In the environmental experiments in which Dwarf milo, feterita, and Dawn kafir were grown for several years at the Arlington Experimental Farm, Va., Amarillo, Tex., and Chico, Calif., from seed produced at each of the three stations, it was shown that the source of seed had practically no influence on the growth of the crop and on yield. Chemical analyses of samples from these crops showed that environmental conditions, such as soil and climate, had much more influence on the chemical composition of grain-sorghum seed than did the sources of the seed from which the crop was grown.

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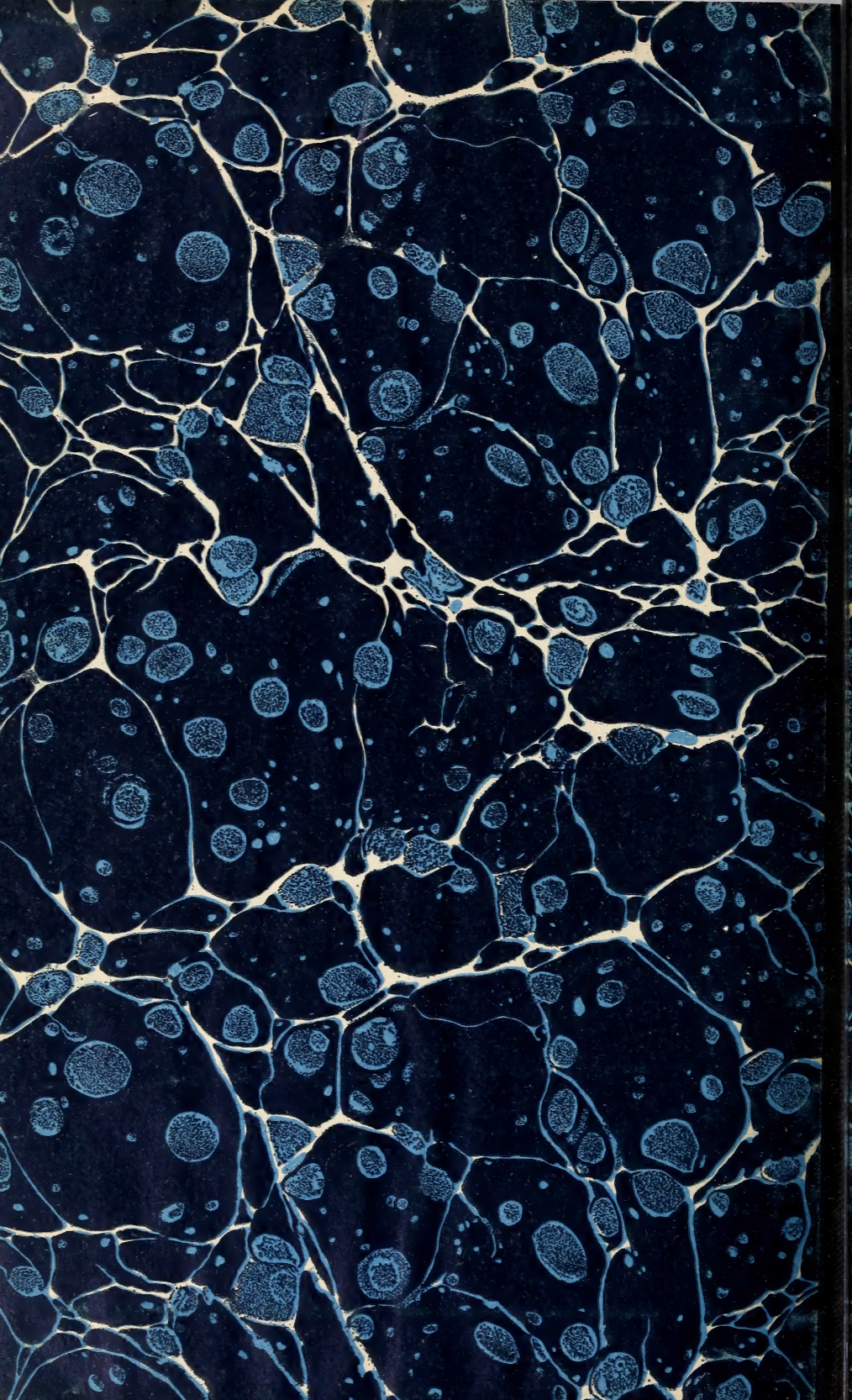

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